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SELECTED ECONOMIC TRANSLATIONS
ON EASTERN EUROPE

(210th in the series)

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SELECTED ECONOMIC TRANSLATIONS ON EASTERN EUROPE

INTRODUCTION

This is a serial publication containing selected translations on all categories of economic subjects and on geography. This report contains translations on subjects listed in the table of contents below. The translations are arranged alphabetically by country.

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CZECHOSLOVAKIA

Principles of Advanced School Training in Geodesy and Cartography at the Advanced Technical School in Prague

[The following is a translation of an article entitled "Prinzipien der Hochschulausbildung in der Geodäesie und Kartographie an der Technischen Hochschule Prag," by Prof Dr Engr J. Boehm, Dean of Faculty for Geodetics, Advanced Technical School, Prague, published in Vermessungstechnik, Vol VII, No 10, October 1959, East Berlin, pages 284-286; CSO: 3942-N/7]

In the year 1705, Christian Josef Willenberg wrote a formal request in the Czech language to Kaiser Leopold, for a certain annual stipend to be paid to six persons from the nobility, four from the gentry, and two from the bourgeoise who wanted to learn the art of engineering. In 1707 Kaiser Josef I granted this request and imposed on the Bohemian classes the task of erecting an engineering school in Prague--the first one of its type in the world.

Today about 9,000 students study at the Advanced Technical School in Prague--the successor to the engineering school of that time, of which 98 percent are sons and daughters of workers, farmers, and the working intelligentsia. These two figures document the astounding upswing in technology and the transition from feudalism to the age of socialism.

* * *

Historical Development

From the very beginning geodesy held a place of honor among the technical disciplines. In earlier times it took its place as "practical geometry" among the construction engineering discipoines. As early as the beginning of the 17th century, Johann Amos Komensky (Comenius), the famous "teacher of nations," who was at the same time known as a geodesist

and cartographer, wrote the first Czech textbook on geodesy. At the end of the 18 century a whole generation of land surveyors who graduated from the Prague Engineering School prepared the maps and the written documents of the "stabile cadaster" as a technical auxiliary aid for the abolition of serfdom and the establishment of a free peasant class. In 1869 there were five institutes in the Prague school, of which the one for geodesy was directed by the famous geodesist, Prof Ritter K. Koristka, who was selected as the first Rector in 1863, when the school enjoyed the status of university.

The historical development of Czech geodesy and political and social relationships are also reflected in the history of the study of geodetics at the Advanced Technical School in Prague. Beginning in 1851 geodesy was split up into lower and higher geodesy with courses on compensating computations, astronomy, and mathematical cartography. From 1891 on, photogrammetry and gravimetry were also included. The assignments in land surveying grew with the industrial and agricultural upswing. The profession of "civil geometer" originated in 1860 and led to the establishment of a special surveying course. A two-year study course came into existence in this connection in 1896; however, the content of this course was unsatisfactory from the beginning. In 1903 the assembly of geometers throughout the entire monarchy called for a four-year course. This requirement of the land surveyors was put forth time and again and was only partially fulfilled in 1927 by the establishment of a three-year study course with the right of promotion. However, the three-year study plan was overloaded with disciplines, and a further lengthening of study to four years was sought for. These efforts were interrupted with the closing of all Czech advanced schools by the German occupation in 1939.

The year 1945 was the most important turning point in the history of geodesy in the Prague Advanced Technical School. This affected not only the new opening of the school and the now finally successful expansion of the geodesy course to four years; the entire social order was changed as we went over to the building of socialism. A constant increase in industrial production, the erection of large-scale construction projects under socialism, a new total state mapping at scales of 1:25,000 and 1:10,000, the socialist reformation of agriculture, city planning, and the upswing in cartographic production brought new and large tasks into surveying engineering.

The school reforms carried out in the following years indicated that an extension of the study program to 10 semesters was necessary. The number of students increased and an annual matriculation of 100 students was planned in the specialized areas of geodesy and cartography. First the four-year and then the later 10-semester study plan made possible sufficient instruction in theoretical foundations. The numerous and diverse requirements of practice in advanced school training then led to a specialization in two areas (geodetic-cartographic and geodetic-economic), which in 1953 was expanded to three areas of specialization.

Special Directions of Advanced School Study in Geodesy

A general education in the basic fields is offered in the first two years of study. Above and beyond this follows training in map drafting on all scales and for the foundations of higher geodesy and cartography in general. Training in several branches is still included in the later years of study. Specialization follows three directions:

1. Geodetic specialization places higher geodesy, astronomy, gravimetry, and the applications of geodesy for engineering and mining in the foreground. In the final semesters students branch off into further special training in photogrammetry.

2. Specialization in the economic and technical regulation of ground parcels (WTR) emphasizes especially the principles of agriculture and planning for the transition to large-scale agricultural production in individual regions.

3. Cartographic specialization emphasizes geography, the drafting of derivative maps, and map reproduction.

The present study plan thus contains 10 semesters (preliminary practice and intermediate practice do not exist), whereby the last semester is reserved for diploma practice and the preparation for diploma work [diploma thesis] in the special field. In these 10 semesters, 15 weeks are used for field exercises. The historical development and the present level of training are compiled in Table 1 (with indication of the semester week-hours and/or weeks for exercises):

Table 1

Discipline	1926	1935	Geo-desy	1959 WTR	Carto-graphy
1. Social science, languages, phsical education	-	-	37	37	37
2. Basic mathematics and physics	34	67	68	68	68
3. Geodesy and map drafting	56 + 2W	79 + 2W	81 + 12W	58 + 10W	62 + 11W
4. Higher geodesy, astronomy, compensating computation	17	28	51 + 2W	23	25
5. Cartography and geography	4	6	18	13	79 + 4W
6. City planning and WTR	7	11	7	30	7
7. Engineering construction	-	8	12 + 1W	18 + 2W	-
8. Agriculture and forestry	6	10	3	23 + 2W	3
9. Economic-legal subjects	19	26	13	18	9
10. Diploma work and practice	-	-	16W	16W	16W
Total	143 + 2W	237 + 2W	290 + 15W*	288 + 15W*	290 + 15W*

*Plus diploma work.

Correspondence study is so far undertaken only for geodetic specialization. The duration of this type of study is six years, and so far about 20 students pass through the program every three years.

Organization of the Faculty

The number of teaching personnel and institutes also increased with the number of students and special branches of study. Initially, geodesy formed a common faculty with mathematical statistics. After the departure of the latter

faculty to the university, for a year geodesy was incorporated into the faculty for construction engineering. In 1953 an independent faculty for geodesy was finally set up in the Advanced Technical School in Prague, which undoubtedly led to a better education for students in engineering and in research work and also better represented Czechoslovak geodesy abroad. The planned quota for this faculty was 500 students and 60 teachers. On 1 October 1959, however, the faculty was again merged with the faculty for construction engineering during a general breakup of small faculties.

The pedagogical and scientif work was organized into five chairs:

1. Mathematics (with the Institute for Calculating Machines)--Prof Pleskot.
2. Geodesy (with a planned geodetic-optical research institute)--Docent Krumphanzl.
3. Map drafting and WTR (with the photogrammetric institute)--Prof Potuzak.
4. Astronomy and geophysics (with an astronomical research observatory)--Prof Buchar.
5. Cartography and higher geodesy (with a cartographic office and reproduction laboratory)--Prof Boehm.

In addition, the chairs for the social sciences, foreign languages, and physical education still aid in the training of students and organize lectures for several faculties under specific situations.

Research Work

Scientific and research work represents the second component which characterizes an advanced school. A certain amount of scientific activity is required from each advanced school teacher.

Valuable research work was carried out in polygonometry, the theory of errors, map reproduction, and cartometry. The most successful so far has been the astronomical observatory, where new instruments (circumzenithal, zenith telescope) were developed and important measurements within the framework of the International Geophysical Year were carried out, as well as the determination of earth flattening from the orbits of the artificial earth satellites.

In the area of publications there is a monthly geodetic journal, an annual for collected large-scale work, as well as faculty reports on conferences and seminars. The periodical of the Academy, Studia geodetica et geophysica, serves as a source of representative works in one of the world's languages.

Connection of the Faculty with Practice

Teaching contracts are given by the faculty to 12 specialists who are practicing in geodesy and related fields. These and other specialists in practice are members of the faculty council and also belong to the commissions for final state examinations. In addition, a basic discussion is held annually between teachers and members in practice on the training of geodetic students. The older teachers, on the other hand, are members of the editorial staffs and the technical or scientific councils in geodetic enterprises. The younger teachers (who have not had long preliminary practical experience) are encouraged to make them selves acquainted with practical work during their vacations, which is also quite frequently done by the students. Diploma practice and diploma assignments also serve practitioners in most cases, who then take over the results of this work.

It has been indicated, however, that the connection between advanced school and practice is still not satisfactory. Therefore, work is being done at the present time on improving advanced schools in the direction of bringing about a closer connection with production and a greater political maturity in students. Here the following principles must be considered:

1. The first semester serves as a period for preliminary practice in an enterprise with predominantly manual labor. Here a third of the time is to be devoted to getting a firm foundation in the principles of mathematics and physics.

2. Specific enterprise assignments are to be selected for the final training practice, and at the end of the eighth semester a monthly enterprise practice is to be completed.

3. In the final (10th) semester the students are already employed in an enterprise as technicians with a salary and there work out diploma assignments which will serve the enterprises.

4. A longer interrelated practice will be made possible to teaching personnel who have not practiced in enterprises.

5. A transfer to correspondence study will be made possible at the end of the sixth and eighth semesters.

6. The faculty will organize seminars for engineers in practice. In addition, an obligatory transfer to an enterprise will be considered in individual special branches after the eighth semester.

Direct study at the advanced school was reduced to eight semesters in order to be able to retain the earlier period of study of 10 semesters. This can be achieved without reducing theoretical and specialized training through a basic revision of the study content, excluding or reducing dispensable abstract or historical parts of lectures. On the other hand, the parts concerning economics, organization and management of geodetic production--which are important for socialist construction, will be expanded. In order to train specialists who are also cabale of solving the most difficult problems, geodetic specialization in the final (ninth) training semester is to be divided into three branches: engineering geodesy, photogrammetry, and higher geodesy (including astronomy and gravimetery).

Cooperation with the Dresden Advanced Technical School

As many tasks of the Faculty of Geodesy of the Prague Advanced Technical School and the Department of Geodesy of the Dresden Advanced Technical School are similarly supported, and as both educational institutions pursue the same goal of educating highly qualified specialists for the building of socialism, this development can be essentially furthered by close cooperation between the two. Therefore, a plan for close cooperation was worked out by the Prague and Dresden schools, which foresees a present exchange of research results, publications, and experiences of all types, reciprocal visits by teachers and students, lectures by Dresden professors in Prague and vice-versa, and an exchange of assistants for long periods. Such cooperation will further progressive development in both our countries and increase still further the great achievements of which socialism makes men capable as this is expressed now in looking back on a past decade in the GDR.

EAST GERMANY

Tasks Resulting from the Law Concerning the Seven-Year Plan

[The following is a translation of an article entitled "Aufgaben aus dem Gesetz ueber den Siebenjahrplan," by Dipl Engr G. Sieber, Chamber of Technology, in Vermessungstechnik, Vol VIII, No 1, January 1960, East Berlin, pages 1-2, 19; CSO: 3942-N/1]

On 1 October 1959 the people's assembly passed a law concerning the Seven-Year Plan for the development of the national economy of the GDR for 1959-1965. The Seven-Year Plan was worked out through the participation of millions of men in all areas and trades on the basis of the resolutions of the Fifth Party Conference of the Socialist Unity Party of Germany. It thereby embodies the collective wisdom of Party, government, and population.

The law concerning the Seven-Year Plan is the basis of work for all state and economic organs. There is also an abundance of tasks for geodesy and cartography.

In June 1959 the VVK [Verwaltung Vermessungs- und Kartenwesen; Geodesy and Cartography Administration] gave out projects for the Seven-Year Plan in surveying and map-making and distributed them for discussion. In these projects the main direction in the development of surveying engineering, geodesy, photogrammetry, topography, topographic cartography, geographic cartography, research and development, and training was indicated. As at that time the discussion on the Seven-Year Plan for the development of the national economy was still not concluded, the assignments for surveying engineering could not be as precisely stated as they were for other areas.

A similar situation developed for geographic and applied cartography. Here the fact that geographic and applied cartography was still not organized in the system of state surveying and maps entered into the picture.

As of 1 January 1960 the historical separation of geographic and applied cartography from topographic cartography was eliminated, thereby creating the organizational conditions for the complex and purposeful solution of all cartographic problems.

Some of the important assignments and work areas which were brough about directly from the law concerning the Seven-Year Plan in regard to surveying engineering and geographic and applied cartography will be elucidated in what follows.

I. Assignments for the Surveying Engineering Area

During the Seven-Year Plan a total of 142 billion DM will be invested, of which 60 billion DM alone will be for industry.

Surveying engineering must above all carry out surveying work for the planning, construction designing, and inspection of the new projects which will arise. This enormous increase in investment undertakings will results in an essentially greater number of surveying jobs. It is therefore necessary in regard to the fulfillment of these assignments to make a survey of the construction investments connected with surveying in the individual branches of the economy.

The development of the power economy is of striking significance for the development of the national economy and for increasing the standard of living of the people. The most important power base of the GDR is raw brown coal.

By 1965 a total coal supply of 278 million tons is to be reached. This means an increase in the supply capacity of 116 million tons. This assignment is to be fulfilled by the expansion of existing mines and the opening of new ones. The point of concentration in coal supply is being centered to an increasing degree in the Niederlausitz region. Six mines will be newly developed in Cottbus Bezirk alone.

Electric power will be increased from 34.9 billion kilowatt hours in 1958 to 63 billion kilowatt hours in 1965. In addition to the thermal electric power plants run on a brown coal base in Luebbenau and Vetschau, an additional large power plant will be built near Baerwalde. At the end of the Seven-

Year Plan the Luebbenau and Vetschau plants will reach an output of 2,300 megawatts. In 1962 the first atomic power plant in the republic will be put into operation near Rheinsburg.

For the first time, 380-kilovolt overhead power lines will be built to conduct electric power from the new power plants to the main consumer areas in Berlin, Halle, Leipzig, and Karl-Marx Stadt. In addition 1,100 kilometers of 220-kilovolt lines and 2,300 kilometers of 110-kilovolt lines will be built. The gas supply, which will increase from 3.1 billion cubic meters in 1958 to 5.8 billion cubic meters in 1965, requires an expansion of the supply network by 4,300 kilometers of main and auxiliary gas lines.

Gross production in the chemical industry will double in comparison to 1958 and will amount to 18 billion DM by 1965. The largest new construction project in this industry is the Schwedt/Oder Petroleum Refining Plant. Petroleum deliveries from the Soviet Union will be conducted to this plant.

The first construction section, which will take up production in 1963, consists of one plant for the production of motor fuels and heating oils.

A chemical fiber combine is being built south of Guben which will have an annual production of 9,000 tons of lanon fibers, 1,000 tons of lanon silk, and 3,000 tons of dederon fine silk. The "Walter Ulbricht" Leuna Plant will be expanded and will have a second plant.

Investments amounting to 30 billion DM will be used for housing construction and construction work in cities. A total of 772,000 dwellings will be constructed during the Seven-Year Plan period, of which 691,000 will be completely new. The centers of the cities destroyed in World War II are to be essentially rebuilt. Housing construction is being concentrated above all in the following cities: Berlin, Leipzig, Dresden, Karl-Marx Stadt, Magdeburg, Rostock, Potsdam, Gera, and Dessau, Frankfurt an der Oder, Neubrandenburg, and others. Above and beyond this, a large-scale housing construction program is to be undertaken in rural communities.

The valley dam reservoir area is to be increased by 327 million cubic meters to 855 million cubic meters for the further development of water management. The largest water management projects are the Bodewerk Valley Dam System, the Poehl Dam and the dam on the Ohra, and the Spremberg Reservoir Basin.

The long-distance and group supply capacity is to be expanded by 627 million cubic meters. The Straussfurt and Kelbra accumulation reservoirs are to be completed for protection against high water in the Unstruttal and in the low country around the Helme. Valley dams are to be built near Rauschenbach, Oberschaar, and Triebelbach to improve the water supply to industry.

Commodity transport is to increase to 140 percent by 1965. The completion of the seaport in Rostock and the Berlin-Rostock Autobahn, with a length of 270 kilometers, are among the large-scale projects of the Seven-Year Plan in the area of transport. In addition, 520 kilometers of railroad lines are to be electrified, 760 kilometers of track are to be laid, 2,700 kilometers of state highways and 5,760 kilometers of bezirk roads are to be improved and/or strengthened and generally speaking expanded; 2,600 kilometers of urban and community streets are to be newly built.

This selection of the most important capital construction in several branches of the national economy will suffice in giving a survey of the assignments which resulted directly from the law concerning the Seven-Year Plan and which concern surveying engineering.

Above and beyond this there are numerous measures contained in the plans of the bezirks and kreises whose execution is connected with surveying engineering.

II. Assignments for Geographic and Applied Cartography

The law concerning the Seven-Year Plan sets three large assignment areas for the production of geographic and thematic maps, which will be treated briefly in the following paragraphs.

The further development of the economic and organizational functions of the state in the period of the Seven-Year Plan places even higher demands on management organs. Maps and atlases of appropriate content are valuable work foundations for the planning and direction of the national economy. In spite of their great factual value, topographical map productions do not alone suffice for these purposes but must be supplemented by special cartographic products. To these

belong planning atlases for the central state organs and the bezirks as well as organizational maps in the scales of 1:50,000 and 1:200,000. The organizational maps are to replace the presently existing kreis and bezirk survey maps.

Besides maps for the management organs, it will be necessary to produce maps for the fulfillment of assignments of individual economic branches. For example, the law concerning the Seven-Year Plan has established that domestic and international flight connections are to be sharply expanded. Airplanes with turbojet engines will now be used; therefore, aerial navigation maps which meet the demands of modern air traffic must be developed. The main task of national education, vocational training, advanced worker qualifications, as well as university and technical school training consists in so perfecting education and training that our people will do justice to the many requirements of life in our socialist society.

The demands placed on maps and atlases as educational and training aids are growing through the obligatory introduction of the 10-grade polytechnical Oberschule [upper-school or high school] for all children by 1964, the construction of enterprise and town academies, the further development of correspondence and night schools, and the further rise in the educational and training level in universities and technical schools.

Besides improving the quality of the products produced, it is also necessary to rapidly close existing gaps in the assortment of maps and atlases.

Some of the products needed by 1965 are the following:

An atlas for the general education polytechnical Oberschule, an atlas for university and technical school study, a historical atlas for the general education polytechnical Oberschule, wall maps for the history of feudalism, capitalism, and socialism, thematic maps for polytechnical instruction, wall maps on the development of the national economy of the GDR and the socialist states, scientific single and text maps.

The further improvement of the cultural level of the life of the people is a main undertaking of the Party and the government. A new stage in the socialist cultural revolution also began with the Seven-Year Plan. The superiority of our

socialist national culture is to be documented through the cultural achievements of the highest national and international level. Workers in geographic and applied cartography can also contribute to fulfilling these aims. The cultural level of performance of cartography in our socialist society can be demonstrated by the production of large world atlas, a national atlas for the GDR, and regional atlases, in accordance with the progressive traditions of German cartography.

The Seven-Year Plan is also oriented to the expansion and supplementation of recreation and the development of sports and tourism. Great significance is to be given in this connection to the production of wall maps, general road maps, city plans, etc. The assortment is to be supplemented by the following: a representative city plan of Leipzig in the German, Russian, English, and French languages; a representative city plan of Berlin in the same languages; the environs of Berlin in book form; a motorist road map of the GDR.

From the above-mentioned discussion it can be established that large and interesting tasks result from the law concerning the Seven-Year Plan for the development of the national economy in all branches of surveying and map-making, and especially in surveying engineering and geographic and applied cartography.

III. Cooperation with Local and Central Organs

Large rights and duties were carried over to the local organs of the state in realizing the law concerning the supplementation and simplification of the work of the state apparatus on 11 February 1958. The great responsibility of local organs in carrying out the plan is expressed, among other things, in the fact that 48 percent of all institutions are within their jurisdiction. In 1965, 31 percent of the industrial gross production will be produced in enterprises subordinate to local councils. Above and beyond this, they are obligated to bring about the socialist reformation of agriculture.

The law concerning the Seven-Year Plan has established that the bezirk and kreis councils, as organs of the people's assembly, are responsible for the fulfillment of the plan in

their territories and the realization of the largest part of the large-scale construction invesyments of the Seven-Year Plan in industry, agriculture, transport, and housing construction. In accordance with the principles of democratic centralism, the tasks of over-all state interest naturally have priority. However, the over-all state interests must be sensibly connected with the interests of the bezirks and kreises.

From the assignments which were transferred to the bezirk and kreis councils for the realization of the Seven-Year Plan it is clear that many problems must be solved by local organs and not by central organs. From this fact arises the necessith of close cooperation between Offices for Surveying Engineering and the bezirk and kreis councils. The directors of the offices bear the full responsibility for seeing that the surveying work for the Seven-Year Plan assignments in their areas is carried out on schedule and in the quality required.

They must confer with the economic councils in the bezirk conncils and the planning commissions in the kreis councils before assignment orders are given them, and they must indicate the many possibilities of support in regard to the tasks of the Seven-Year Plan to be given by the state surveying and map system.

The representatives of the State Geodetic Control [Office] support the Offices for Surveying Engineering in these matters.

The production of planning atlases, organizational maps, and atlases for the general education polytechnical advanced schools, etc. are significant throughout the GDR. The problems connected with this are to be solved through the cooperation of colleagues in the executing enterprises of the VVK with the appropriate central state organs. The establishment of still closer connections with the central and local organs is especially important in regard to surveying engineering as well as to geographic and applied cartography, as both fields have the closest relationship with each other and to the tasks set forth in the law concerning the Seven-Year Plan.

EAST GERMANY

Photogrammetric Work for Forestry of the GDR

[The following is a translation of an article entitled "Photogrammetrische Arbeiten in der Forst-Wirtschaft der DDR," by R. Totel and H. Ehrig, Institute for Forest Organization and Location Reconnaissance (Institut fuer Forsteinrichtung und Standorterkundung), Potsdam, published in Vermessungstechnik, Vol VIII, No 1, January 1960, East Gerlin, pages 8-10; CSO: 3942-N/2]

Introductory work in the field of photogrammetry began in 1957 in the forestry of the GDR, especially in forest organization. Here first of all it was necessary to clarify the essential problems of aerial photographic interpretation in forestry. This assignment was fulfilled in the joint research work between the Institute for Forest Organization of the Faculty in Tharandt and the Institute for Forest Organization and Location Reconnaissance in Potsdam. These undertakings had to be considered urgent on the basis of the special assignment given to forest organization. It can be said today that the possibilities of applying aerial photographs in the field of forestry photo interpretation were exhaustingly investigated. In the meantime, the aerial photograph has already found a broad application here.

The situation is different in regard to forestry photogrammetry. Here we are not concerned with new forest territory; large forest areas were flown over and photogrammetrically processed already in the 1920's and the beginning of the 1930's (Nuernberger Reichswald, Baerenthoren/Anhalt, Tharandter Wald). In the meantime, the method of forest organization and/or forest surveying was changed, and frequently the requirements for a forestry map product were increased, also with regard to the completeness of forest detail reproduction and exactness and economic importance.

Taking these circumstances into account, large-scale investigations have been made since 1958 in the Institute for Forest Organization and Location Reconnaissance which were to provide information on the following questions:

1. What possibilities exist in the application of an aerial photograph for forestry surveying?
2. What methods can be used?
3. What accuracy will be obtained?
4. What benefit can we count on?

The point of departure in each case was the forest organization method practiced in the GDR.

We shall not go closely into the problems of classical forestry surveying here. It will suffice to state that after the formation of the Office for Surveying Engineering, only forestry detail surveys are being made--the photographing of subsections (marked section units), partial surfaces (unmarked stock borders altered by economic encroachments), as well as timber transport lines and the various other areas serving wood production indirectly. Above and beyond this are required quite extensive photographs of roads and footpaths or streams which are significant for forestry purposes but which, in regard to the fundamental surveying, are not especially important. Here basically compass surveying is used. If simple conditions exist--for example, in the linear course of the stock borders, measurements by means of a measuring tape or occasionally with the aid of an optical square will suffice.

The Photogrammetric Process

It is apparent from the foregoing statements that we can make use of simpler methods in forestry photogrammetry. This is even quite necessary in regard to economy. We must clarify in regard to the investigations carried out here whether such simple methods of plotting will lead to sufficient precise results. The equipment available is also a major factor in determining the type of method used.

In the present institute at the present time, only rectifying (SEG I and aerial photograph transformation drawing equipment) is concerned. With this equipment about 50 percent of the surface areas to be orientated at any given time within a 10-year cycle in the GDR can be photogrammetrically plotted, since the remaining part of the forests are located in hilly country and highlands. We must proceed from the following viewpoints in selecting individual processes:

a) In general, radial triangulation is superfluous, since many detailed maps at a scale of 1:5,000 are already available. Where at the present time only new measurements will

be made, only property lines, public roads, trestles, and some forest aisles will be plotted according to the classical method. Marked, plainly visible points on the aerial photograph of property lines as well as road crossings and the intersection points of trestles or forest aisles serve as points of minor control for rectifying. Only where the net is too loose on the basis of the natural data of these points will a concentration of minor control points be made through radial triangulation.

b) Since so far no negatives have been available for rectifying, we have had to proceed from paper positives. For this purpose, all turning points of the forest detail and the accepted "points of minor control" are pinpointed on the contact print before rectifying. Thereby the sums of the radial displacements, determined mostly by the different elevations of the stock, are considered. The radial displacement is either calculated or simply read by means of a scale (Figure 1). The heights of the trees can, with some practice, be quite accurately evaluated under the stereoscope. Comparative investigations have shown that an evaluation with a mean deviation of ± 2 is possible.

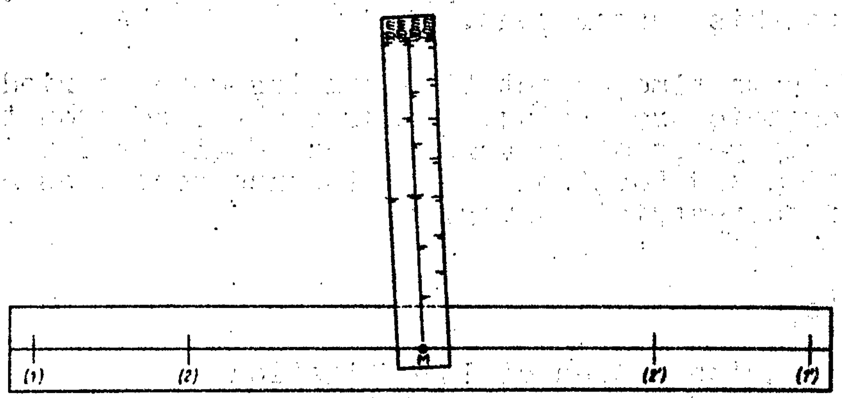

Figure 1

A Scale for Reading Radial Displacement. The line (1) (1') or (2) (2') (30 or 18 centimeters) is laid on the picture so that M represents the middle point of the picture. The corresponding sums of radial displacement are then plotted on the scale, which moves around M, for the different radial distances from M and for different Δh values. With some practice, intermediate values can be estimated accurately enough. The scale is made for Δh values of 10, 20, 30, and 40 meters and for different radial distances (for example, Δh = 30 meters on a 2-centimeter scale and 40 meters on a 1.5-centimeter scale).

c) After rectifying, the pinpointed lines are either immediately transferred to the detail map or are recorded photographically. In the latter case, the elevation delineation (clear cell nut interval [Klarzellmutterpause]) takes place over the light box. Evaluation of paper distortion is considered during examination of the work.

d) The forest surveyor marks the partial area borders, roads, etc. to be taken in the aerial photograph. The perforating is undertaken in the photogrammetric plotting. An elimination [of prints?] without a field comparison does not lead to satisfactory results.

Test Measurements

It was worth while to test with what accuracy and expenditure photogrammetric plotting could be undertaken in comparison with the old method. For this purpose, an exact stadia survey (theodolite 030, mechanical interval or line measurement) was carried out in areas already surveyed with the compass; the closing errors of this survey remained within the allowable error limits for transit traverses. The results of the compass measurement and photogrammetric plotting are applied to this measurement.

At the same time, exact time studies were carried out in the photogrammetric processing. Figures obtained from the experience of many years of workers in the Institute for Forest Organization and Location Reconnaissance served as comparison values of terrestrial survey.

Results:

1. Haldensleben Area of Investigation

Stock: pure fir or pine stocks, partly with admixtures of less than 20 percent.

Area (in hectares)	200
Maximum difference in ground elevation (meters)	43
Picture scale	1:11,000
Focal length (millimeters)	200
Picture quality	Good
Forward lap (percent)	15-30
Side lap (percent, average)	Up to 15
Working scale	1:5,000

The pictures were cut in the SEG I into a 24 x 24 centimeter size for plotting. Rectification in regard to the elevation zones was not done. In relation to control measurement, the following values resulted from adjustment by the method of least squares:

Section comparison

Compass measurement (meters)	$m_s = \pm 3.5$
Photogrammetric plotting (meters)	$m_s = \pm 3.4$

Point comparison

Compass measurement (meters)	$m_p = \pm 5.1$
Photogrammetric plotting (meters)	$m_p = \pm 4.9$

Area comparison

Compass measurement (a/hectare)	$m_f = \pm 4.45$
Photogrammetric plotting (a/hectare)	$M = \pm 4.55$

As here only the areas bounded by trails, aisles, and firebreaks were considered--a total of 20 areas--these values which were obtained according to the following formula may be viewed as not very accurate:

$$(1) \qquad m_f = \sqrt{\frac{p[\varepsilon\varepsilon]}{n}}; \; p = \frac{1}{F}$$

2. Supplementary Investigations in the Friedrichshagen Area

Stock: pure fir or pine stock, also with an admixture of deciduous wood up to 20 percent.

Area (hectares)	65
Maximum difference in ground elevation (meters)	10
Picture scale	1:12,000
Focal length (millimeters)	200
Format (centimeters)	30 x 30
Forward lap (percent)	60
Side lap (percent, average)	30
Picture quality	Unsatisfactory
Working scale	1:5,000

The work carried out in this area was concentrated on partial area measurement. The separation of these areas in the forest took place on the aerial photograph, and the individual breaks were pinpointed and marked for the natural terrestrial survey. Only a point and area comparison was made.

Point comparison (meters)

Compass measurement	$m_p = \pm 5.4$
Photogrammetric plotting	$m_p = \pm 4.5$

Area comparison; total of 30 areas (a/hectare)

Compass measurement	$m_f = \pm 5.5$
Photogrammetric plotting	$m_f = \pm 4.3$

3. Investigations Concerning Point Transfers

In order to obtain better information on the accuracy of point transfers from forested terrain to aerial photographs, the position of existing subsectional stone [markers], which are otherwise measured with a compass, over an area of about 250 hectares, was perforated in the aerial photograph. It was established by this method that the markers lying on aisles, paths, and stock borders could be quicly and accurately transferred to the aerial photograph. Several difficulties were encountered in transferring the markers in the middle of stocks, especially from uniformly stocked areas.

Rectification in the SEG was made after the ground point transfer.

Picture scale	1:8,300
Format	18 x 19 cm
	f = 200 mm
Working scale	1:5,000
Maximum difference in ground elevation (rectifying in two zones)	65 meters

For purposes of comparison, these border traverses were surveyed exactly with a compass. The following picture resulted for a count of 52 stone markers which were placed at an average distance of 85 meters:

Section comparison (meters)	$m_s = \pm 5.6$
Point comparison (meters)	$m_p = \pm 5.5$
Area comparison (areas per hectare)	$m_f = \pm 3.0$

The average labor expenditure in locating and perforating was 4.9 minutes per stone marker.

Even if the scope of these investigations did not lead to conclusive and accurate results, nevertheless several final conclusions which are not to be underrated resulted.

All deviations lay within the limits of error of up to two areas. This work must be given further consideration. Proceeding from the fact that all forest elevations are in the final analysis related to the areas, logically the question arises as to whether a terrestrial point survey of this type of line is not somewhat superfluous. Further attempts on a larger area are planned.

Time Studies

Taking as a basis the fact that for simple forest surveys of a determined scope semi-skilled workers are used and that only qualified work is carried out by surveying technicians, the results for the processing of 265 hectares of terrestrial surveying are (in minutes):

Field work--professional personnel	2,650
Indoor work--auxiliary personnel	2,220
Total	4,860

and for photogrammetric plotting:

Preliminary work (picture preparation, selection of rectifying points)	20
Pinpointing [perforating], rectifying, and tracing	370
Field comparison	100
Total	490

Photogrammetric plotting brings about, according to this, a savings of 4,370 minutes, or about 90 percent.

The cost considerations give the following picture (without unproductive costs and administrative costs):

Terrestrial surveying (in DM)

Work of auxiliary and professional personnel	260

Photogrammetric plotting (without unproductive costs, which here are smaller than those for terrestrial surveys, and without considering equipment costs):

Work of auxiliary personnel	12
Work of professional personnel	14
Terrestrial surveys still to be made*	26
Cost of picture materials,** chemicals, and other materials	4
Total	56

*Investigations have shown that about 90 percent of the borders to be surveyed are visible from the air. The area alterations which come about by the age of the picture amount to about 10 percent in partial area surveying.

**Here a price of 1.44 DM per picture was fixed.

This amounts to a saving of about 80 percent.

Conclusions

If we can evaluate here only the accuracy of the work undertaken as a result of a comparison of two methods, the work nevertheless shows that we can no longer abandone the use of the aerial photograph for forestrydetail surveying in the future.

The work method described here must still be characterized as complicated. An additional increase in performance will appear when negatives are available for rectifying work, the quality of the pictures improves, and we can work with a picture format of 18 x 18 centimeters.

In particular, we can stand pat on the following:

1. Taking as a basis the accuracy requirements on the topographical map, scale 1:5,000 (mean position accuracy in forest areas, ± 7 meters) and, in considering the accuracy of the

usual forest compass survey, the results of photogrammetric plotting lie within the allowable limits of error. They reach in no case (in regard to 1 and 2) the maximum magnitude of error in terrestrial surveying.

2. For a similar or higher accuracy in photogrammetric plotting, an increase in labor productivity averaging 75 percent will be reached, taking lesser factors into consideration.

3. An exact as possible rectifying foundation is decisive for the orderly execution of the methods described. Here detailed forest maps or cadastral maps are involved. Care must be taken to select polygon or tachymeter stations as rectifying points.

4. The plotter must have special knowledge of the field of forest organization.

5. An increase in accuracy is possible with the use of negatives. In working with paper prints, the border lines between the individually pinpointed points cannot always be clearly recognized because of the low penetrability to light.

6. The aerial photographs used for forestry purposes must have an optimum light-shade distribution, and not only for interpretation; this holds true only to a special degree in regard to the latter.

An accurate separation of paths, slopes, and stocks is possible only when the relative shadow length does not exceed the value of 1.5

In summary, we can state that the photogrammetric work practiced in our institute today does justice to the accuracy requirements of our forest organization method. The fact that for lack of a simple, cheap, and accurate working apparatus for plotting aerial photographs of mountainous terrain, about one half of the forest areas in the GDR cannot be photogrammetrically processed should spur industry to develop suitable designs of small equipment of a type which could surely find application in several branches of the economy.

1907

EAST GERMANY

The Quasi-Geoid and the Standard Elevations

[The following is a translation of an article entitled, "Das Quasigeoid und die Normalhoehen," by K. Mueller, Chamber of Technology, scientific colleague of the Leipsiz Geodetic Service, published in Vermessungstechnik, Vol VIII, No 2, February 1960, East Berlin, pages 36-40; CSO: 3942-N/3]

1. Historical Introduction

The determination of the figure of the earth is described as the main problem in higher geodesy. In the course of development, this problem was solved by successive approximations. The Russian geodesist Sludskiy speaks of three stages of approximation, to which still a fourth is to be added.

In antiquity, the develepment in the knowledge of the form of the earth progressed from the idea of the apparent disk to that of the sphere. Only in the 18th century was the flattening of the sphere into a spheroid recognized through the work of Newton, Huygens, and Clairaut. The expansion of the potential theory by C. F. Gauss led, in the 19th century, to the discovery of the level surfaces. The wrinkled character of the surface of the earth was discovered and the development went from spheroid to geoid. Finally, in our time the problem of the hypothesis-free reduction of measured geodetic areas onto the reference surface led to the introduction of auxiliary surfaces, among which the well-founded quasi-geoid is of outstanding significance.

2. Concerning Several Necessary Basic Concepts of Gravimetry

The earth with its oceans, continents, and islands comprises on its surface the so-called "physical" or "topographical" outer terrestrial surface. Were this surface completely covered with water, the water masses, since the forces of gravitation are in balance with the centrifugal forces of revolution, would fill out with their surface a "level surface."

This fact led Gauss and Listing to the definition of the shape of the earth as a surface which is formed by the outer surface of the calm oceans and their continuation under the continents and islands with a condition of orthogonality in regard to the plumb or force lines of the physical earth. This surface was named a "geoid" by Listing. This geoid is mathematically just as indeterminable rigorously as the physical earth itself, although it is constant everywhere, and, as surveys so far have shown, it is highly probable that it has a radius of curvature in all places which is directed inward.

All level surfaces, especially so the geoid, are by definition perpendicular to the force or plumb lines of the real earth. Consequently, the acceleration or gravity vectors $\vec{g}$ of the earth's field belonging to the points of a level surface are perpendicular at these points to the level surface.

No work is performed in a movement of mass along a path on a level surface of the gravitational field of the earth, apart from friction forces, as the path of work is perpendicular to the force lines

A mass m possesses on a level surface a constant potential energy mW = const. If the mass is equal to 1, then W is the potential on this surface.

The equation of the band of the level surfaces calls accordingly for an arbitrary C:

$$W = C = \text{const.}$$

Level surfaces are also called equipotential surfaces. The potential has in the "CGS system" the dimension $cm^2\ S^{-2}$. For the geoid, the following formula holds true:

$$W = W_o = C_o \tag{1}$$

The accuracy of W_o depends on the determination of earth masses, and, in regard to the present state of the sciences, is still unsatisfactory.

In transferring from an equipotential surface where W = const. along an arbitrary path $\vec{ds}$ to a neighboring equipotential surface where W + dW = const. with dW $\neq$ 0, we get the alteration of dW as work dA for the movement per unit of mass along the path $\vec{ds}$:

(2) $$dA : \text{Masse } 1 = dW = \vec{g}\,d\vec{s}.$$

For the elementary path dn in the direction of the inner normals $\vec{n}$ of the equipotential surface, the following shall hold true:

(3) $$dW = \vec{g}\,d\vec{n}$$

Then the path element dh directed in the opposite direction to the elementary path dn will be:

(4) $$dW = -\vec{g}\,d\vec{h}.$$

If one compares two neighboring equipotential surfaces where W = const and W + dW = const, we will then have, according to (4):

(4a) $$(W + dW) - W = dW = -\vec{g}\,d\vec{h} = \text{const} \neq 0,$$

where $\vec{dh}$ represents the distance of the two equipotential surfaces. From this it follows that two equipotential surfaces cannot intersect, as otherwise contrary to the premi $dW \neq 0$ for their line of intersection, for which dh = 0 would be true, the equation $dW = -\vec{g}\ \vec{dh} = 0$ **would** have to hold.

It is already recognized in observing the earth as a rotating, homogeneous sphere of mass of angular velocity ω, that the acceleration g at point P of latitude φ depends on this; g_φ is made up vectorally of the pure gravitational acceleration g of the static sphere and the acceleration $\omega^2 R \cos\varphi = f_\varphi$ of rotation. As Figure 1 illustrates:

$$g_\varphi = \sqrt{g^2 + f_\varphi^2 - 2 g f_\varphi \cos\varphi} \approx g - \omega^2 R \cos^2\varphi.$$

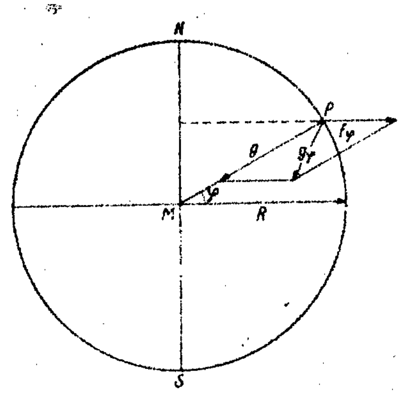

Figure 1

This equation is sure to be altered somewhat by the flattening of the earth and by the lack of homogeneity of its mass, but the variability of g with the latitude is retained, as surveys confirm. This holds true for the free oceans as also for the geoid as an equipotential surface, from which then the variation in g for all equipotential surfaces can be deduced. When, however, g is variable on the equipotential surfaces and, according to (4a), g dh is to be constant, it then follows that the distance dh must be variable. Consequently, equipotential surfaces cannot run parallel to each other.

The geoid is by definition a self-contained equipotential surface. Therefore, it follows from the above characteristics of equipotential surfaces that they are self-contained surfaces. This Pizetti has shown for equipotential surfaces which extend into the interior of the earth to a depth of about 500 kilometers and for those in outer space to a distance of about 30,000 kilometers, from which results the irrotation of the outer gravitational field of the earth. In movement of mass between two points A and B of this field, the work produced then will be independent of the path on which it is being performed.

3. The Orthometric Elevations

Whenever in A the potential W_A prevails and in B the potential W_B prevails, then the following occurs by the integration of (4) along an arbitrary path between A and B:

(5) $$W_B - W_A = -\int_A^B g\,\mathrm{d}h.$$

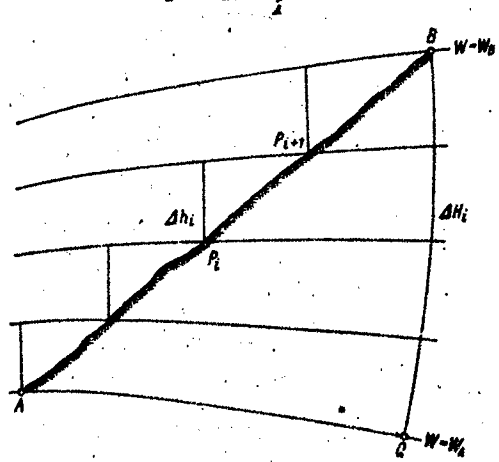

Figure 2

As is indicated in Figure 2, Q represents the point of intersection of the plumb line running through B with the equipotential surface of A. If one integrates in (5) on one path of the equipotential surface $W = W_A$ from A to Q and from Q to B along the plumb line, the following equation is obtained:

(5a) $$-(W_B - W_A) = \int_A^Q g\,\mathrm{d}\bar{h} + \int_Q^B \bar{g}\,\mathrm{d}H.$$

where for $\bar{g}$ in the last integral, the functional relation of $\bar{g}$ is to be indicated with respect to the integration variables. For the first integral on the right side, the following equation holds:

(5b) $$\int_A^Q g\,\mathrm{d}\bar{h} = (W_Q - W_A) = 0,$$

as $W_Q = W_A$.

Equation (5a) then becomes:

(6) $$\int_A^B g\,\mathrm{d}h = \int_Q^B \bar{g}\,\mathrm{d}H.$$

In the following, A and Q were selected on the geoid.

According to the mean value theorem of integral calculus, we obtain for a suitable selected mean value g_m of $\bar{g}$ between the gravity values from Q and B the following:

(7) $$\int_Q^B \bar{g}\,dH = g_m \int_Q^B dH = g_m \cdot H;$$

since dH represents the element of arc of the curved integration path and so becomes:

(7a) $$\int_Q^B dH$$

equal to the length H of the plumb line from geoid point Q to point B of the physical surface of the earth.

In geodesy this length is defined as the "true orthometric" elevation, and we obtain from (6) and (7):

(8) $$H = \frac{1}{g_m} \int_A^B g\,dh.$$

In this definition-equation, the integral on the right side is an area measurable with good accuracy, for by the approximation of sums we obtain:

(8a) $$\int_A^B g\,dh \approx \sum_{i=1}^{n} g_i \cdot \Delta h_i.$$

where Δh_i is equal to the difference in elevation by spirit leveling between sufficiently close temporary points P_i and P_{i+1} of the level line from A to B on the ground, and g_i represents an acceleration value measured between P_i and P_{i+1}. The integral is then sufficiently exactly approximated for a sufficiently dense series of temporary points P_i ($i = 1, 2, \ldots n$). For g_m we obtain from equations (8) and (6):

(8b) $$g_m = \frac{1}{H} \int_A^B g\,dh = \frac{1}{H} \int_Q^B \bar{g}\,dH.$$

If by way of approximation the last integral is solved by summation, the following is obtained from (8a):

$$g_m = \frac{1}{H} \sum_{i=1}^{n} \bar{g}_i \cdot \Delta H_i.$$

4

By selecting here $\Delta H_i = H:n$, the following is obtained:

$$g_m = \frac{1}{H}\cdot\frac{H}{n}\sum_{i=1}^{n}\bar{g}_i = \frac{1}{n}\sum_{i=1}^{n}\bar{g}_i.$$

Now $\bar{g}$ varies almost linearly along the path H from Q to B, so that in equidistant stationing we obtain:

(9) $$\bar{g}_i = \bar{g}_{i-1} + \Delta g \qquad (i = 1, 2, \ldots, n)$$

It thus becomes:

(10) $$\left.\begin{array}{l} \bar{g}_1 = \bar{g}_1 \\ \bar{g}_2 = \bar{g}_1 + \Delta g \\ \bar{g}_3 = \bar{g}_2 + \Delta g = \bar{g}_1 + 2\Delta g \\ \ldots\ldots\ldots\ldots\ldots \\ \bar{g}_n = \bar{g}_{n-1} + \Delta g = \bar{g}_1 + (n-1)\cdot\Delta g \end{array}\right\}$$

All equations added give the following:

(11) $$\begin{aligned} \sum_{i=1}^{n}\bar{g}_i &= n\bar{g}_1 + \Delta g\sum_{i=1}^{n-1} i = n\bar{g}_1 + \frac{n(n-1)}{2}\Delta g \\ &= \frac{n}{2}(2\bar{g}_1 + (n-1)\cdot\Delta g) = \frac{n}{2}(\bar{g}_1 + \bar{g}_1 + (n-1)\cdot\Delta g) \\ &= \frac{n}{2}(\bar{g}_1 + \bar{g}_n). \end{aligned}$$

Therefore we obtain:

(12) $$g_m = \frac{1}{n}\sum_{i=1}^{n}\bar{g}_i = \frac{1}{2}(\bar{g}_1 + \bar{g}_n).$$

Here $\bar{g}_1$ is probably measurable at B, but $\bar{g}_n$ as a value on the geoid running in the interior of the earth remains inacessible for measurement.

With the help of hypotheses concerning the density of the mass supported over Q, we can now calculate a value $\bar{g}_n$ by any known reduction method. As, however, in reality the density for all points of the path H from B to Q is unknown, in the last analysis the obtained value $\bar{g}_n$ remains affected by the uncertainty of the hypothesis. Errors can be produced through the use of the $\bar{g}_n$ values which are far greater than the average errors in the survey by levels carried out, whereby their merit is sharply decreased.

4. The Standard Elevations

The elevations have a double character. They are, as the distance of a point from a surface, purely mathematical dimensions and, as a potential difference, divided by a gravity acceleration of a physical nature. Therefore, the concept of elevation allows a twofold interpretation. On

the one hand we can understand the elevation of a point as its geometrical distance from the geoid. The geoid is here the primary factor and the elevations are obtained from it secondarily as distances of the points on the surface of the earth. On the other hand, the elevations are defined primarily according to formula (8), because of their physical character as the quotient of a potential difference, by a gravity accleration value, and the geoid is obtained secondarily as the geometric locus of all points whose distance--measured along the curved plumb line in the direction of the inner normals to the physical surface of the earth--is equal to the true orthometric elevation. The concept of the second interpretation will be proved to be fruitful in section 5 and will lead to a new surface--the quasi-geoid.

It goes without saying that both interpretations remain basically the same, but they indicate that elevation and geoid have a mutual relationship. The one concept is given with the definition of the other concept. Under full consideration of these two real conditions of elevations, we shall, in what follows, define an elevation, the standard elevation, which, free of hypothesis, can be obtained exactly from measurements of geometric leveling and from physical measurements of a gravimetric type.

The Soviet geodesist, M. S. Modolyenskiy, shows the way here in his noteworthy works, and we shall follow the same road.

Let us imagine a model earth (regularized earth) in the form of a material ellipsoid of revolution with the following characteristics:

1. The model earth is equal in mass to the real earth in the case of homogeneous distribution of mass.

2. The center of gravity of the model earth and the real earth are to be identical.

3. Regularized and real earth are to have a common axis of rotation.

4. The angular velocities of the model and of the real earth are to be equal.

5. The potential $U_0 = W_0 = C_0$ will prevail on the surface of the model earth, where W_0 represents the potential on the geoid

The gravitational field produced by the model earth, the "normal gravitational field," is to have the equipotential surfaces $U = C = \text{const.}$ For this, analogous to (4), the following equation will hold:

$$(13) \qquad dU = -\vec{\gamma}\,\vec{dh}$$

with $\vec{g}$ as the acceleration vector of the normal gravity field.

According to the laws of the potential theory, the "normal gravity value" γ is calculable given the known measurements and the known density of the model earth, and the equipotential surfaces become rotational surfaces. If γ_e is the normal gravity value at the equator and γ_p that at the pole, then the following is valid for γ_k on the surface of the model earth in the latitude φ:

$$(13a) \qquad \gamma_k = \gamma_e(1 + \beta \sin^2 \varphi)$$

with: $\beta = \frac{\gamma_p - \gamma_e}{\gamma_e}$

As the model earth has no mass overhanging its surface, the gravity value γ is to be calculated with the help of the "free-air reduction" formula for all points outside of it:

$$(14) \qquad \gamma = \gamma_k\left(1 - 2\frac{H}{R}\right)$$

In the normal gravity field of the model earth, U_B, as is indicated in Figure 3, is the normal potential of the equipotential surface passing through B; in general U_B differs from the true potential W_B prevailing at B. If the equipotential surface $U = W_B$, which may intersect the normal plumb line through B at B' is observed, and if the normal plumb lines through A and B meet the surface of the model earth at O and D, then the potential difference between the points O and B' is equal to $U_{B'} - U_O$.

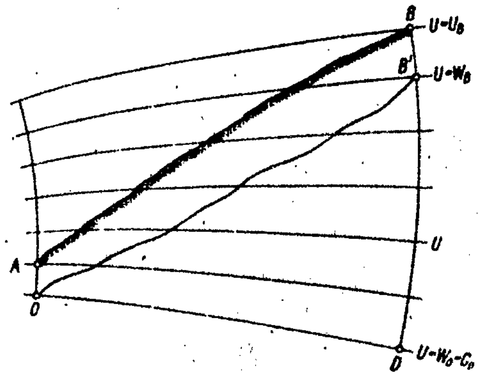

Figure 3

Because of the definition of point B', and as a consequence of characteristic No 5 of the model earth, the following holds true:

(15) $$U_{B'} - U_o = W_B - W_o$$

Analogous observations to (5) giver further:

(16) $$U_{B'} - U_0 = -\int_0^{B'} \gamma \, dh = -\int_0^{D} \gamma \, d\overline{h'} - \int_D^{B'} \bar{\gamma} \, d\overline{H},$$

and we also have, as in (5b):

(17) $$\int_0^{D} \gamma \, d\overline{h'} = 0.$$

It also follows from (15), (16), and (17), as in (6):

(18) $$W_B - W_0 = -\int_D^{B'} \bar{\gamma} \, d\overline{H}.$$

We will then obtain, again according to the mean value theorem of integral calculus, the following for a suitably selected intermediate value γ_m from $\overline{\gamma}$:

(19) $$W_0 - W_B = \gamma_m \int_D^{B'} d\overline{H}.$$

Here dH is the element of arc of the normal curved plumb line through B, and the integral (19) represents the plumb line itself from D to B'. Thus, with H as the length of the plumb line, we obtain:

(20) $$W_0 - W_B = \gamma_m \cdot \overline{H}.$$

From (20) and (18) we obtain:

(21) $$\gamma_m = \frac{W_0 - W_a}{\bar{H}} = \frac{1}{\bar{H}} \int_0^{\bar{H}} \bar{\gamma}\, d\bar{H}.$$

By the summation approximation of the integral in (21), we obtain:

(22) $$\frac{1}{\bar{H}} \int_0^{\bar{H}} \bar{\gamma}\, d\bar{H} \sim \frac{1}{\bar{H}} \sum_{i=1}^{n} \bar{\gamma}_i \Delta \bar{H}_i.$$

If from this is selected: $\Delta \bar{H}_i = \frac{1}{n} \bar{H},$

the following is obtained from (21):

(23) $$\gamma_m \sim \frac{1}{\bar{H}} \cdot \frac{\bar{H}}{n} \sum_{i=1}^{n} \bar{\gamma}_i = \frac{1}{n} \cdot \sum_{i=1}^{n} \bar{\gamma}_i.$$

Because of the formula for free-air reduction (14), $\bar{\gamma}_i$ is altered linearly and, as in (9), becomes:

(24) $$\bar{\gamma}_i = \bar{\gamma}_{i-1} + \Delta \gamma,$$

from which it follow, in exactly the same manner as in (10), (11), and (12):

(25) $$\gamma_m = \frac{1}{n} \sum_{i=1}^{n} \gamma_i = \frac{1}{2} (\bar{\gamma}_1 + \bar{\gamma}_n).$$

We then obtain, whenever $\bar{\gamma}_1$ lies on the surface of the model earth:

(26) $$\bar{\gamma}_1 = \gamma_k$$

and because of (14) we obtain:

(27) $$\bar{\gamma}_n = \gamma_k \left(1 - 2 \frac{\bar{H}}{R}\right).$$

For (26) and (27), (25) gives:

(28) $$\gamma_m = \frac{1}{2} \left(\gamma_k + \gamma_k - 2 \gamma_k \frac{\bar{H}}{R}\right) = \gamma_k \left(1 - \frac{\bar{H}}{R}\right).$$

Therefore, γ_m is exactly calculable for practical purposes, as for $\overline{H}$ again the rough elevation obtained from leveling may be applied, and γ_k are R and known with sufficient accuracy.

A new elevation is then defined, according to Modolyenskiy, the "standard elevation," by the following formula:

$$\overline{H} = \frac{W_o - W_B}{\gamma_m} \tag{29}$$

for point B. It is, however, because of the selection of points A and B:

$$W_o - W_B = \int_A^B g\,dh \tag{29a}$$

and for it:

$$\overline{H} = \frac{1}{\gamma_m}\int_A^B g\,dh. \tag{30}$$

This so defined elevation is exactly determinable and requires no hypotheses concerning the density of any sort of mass for its calculation.

5. The Quasi-Geoid and Its Characteristics

With the aid of these standard elevations, a surface is defined which generally projects only a few dm from the geoid, the "quasi-geoid," as the geometric locus of all points whose distances from the physical surface of the earth along the curved plumb lines of the normal gravity field on the ellipsoid of reference are dquat to the standard elevations.

Thus the standard elevations $\overline{H}$ are plotted from points B of the physical surface of the earth along the normal plumb lines in the direction of the inner normals to Q. The terminus Q satisfies the quasi-geoid. The distance of the quasi-geoid point Q from plumb point D of the plumb from Q onto the reference surface is the elevation of the quasi-geoid. From Figure 4, we have the following:

$$\zeta = B'B = DQ.$$

The distance of the measured geodetic quantity of points of the physical surface of the earth from the reference ellipsoid sought for reduction purposes is therefore split up into two parts: a geoidal, slowly changing part ζ , the quasi-geoid elevation; and a hypsometric, more rapidly and irregularly changing part $\bar{H}$, the standard elevation; it thus becomes equal to:

$$\zeta+\bar{H}.$$

The standard elevation $\bar{H}$ defined by Molodyenskiy generally deviates only a little from the true orthometric elevation $\bar{H}$, for the following equation holds true for the difference in both elevations:

$$\Delta H=\bar{H}-H=\frac{W_0-W}{\gamma_m}-\frac{W_0-W}{g_m}=\frac{g_m-\gamma_m}{g_m}\cdot\frac{W_0-W}{\gamma_m}$$
$$=\frac{g_m-\gamma_m}{g_m}\cdot\bar{H}.$$

In practice, the gravity values are measured as acceleration in cm s^{-2} = Gal. The thousandth part of a gal is termed a milligal and is abbreviated mGal. The difference between the true and the normal gravity value of a point is called the "true gravity anomaly."

The anomaly $g_m - \gamma_m$ which appears in ΔH does not refer to one and the same point, for g_m is valid for the central point of the plumb line of an outer point of the true gravity field up to the geoid, while γ_m, on the other hand, refers to the central point of the plumb line of the normal gravity field of the same outer point up to the surface of the quasi-geoid. Both plumb lines are not identical, and correspondingly their central points or centers are also not identical. Molodyenskiy calls this type of anomaly "mixed," to differentiate it from the true anomalies, in which g and γ refer to one and the same point, and from the apparent anomalies, in which g refers to the geoid and γ to the level spheroid $U = W_0$.

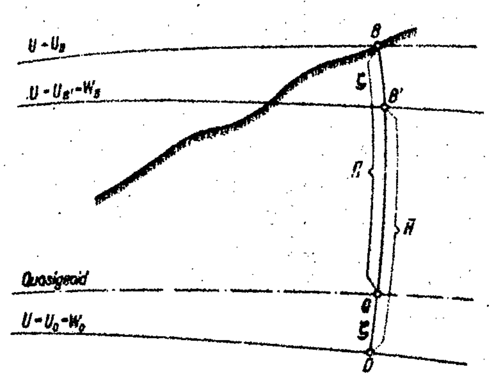

Figure 4

For a mean mixed anomaly of 100 mGal and an elevation of 2,000 meters ΔH would only reach a value of 0.20 meters, as g amounts to approximately one million mGal. In the maximum case, this deviation does not reach 2 meters.

The quasi-geoid as defined by Molodyenskiy coincides at the points of the oceans, and at the points at which $g = \gamma$ with the geoid; it touches the geoid at the shores of the continents and islands. On a horizontal segment of the surface of the earth of arbitrary boundary, the normals of the quasi-geoid and the equipotential surface adjacent to the surface of the earth have the same form. However, the more the surface of the earth deflects from the horizontal and the greater the gravity anomaly is, the greater will be the angle enclosed between the normals of the quasi-geoid and the plumb direction on the surface of the earth; this angle can increase on steep mountain slopes to 20".

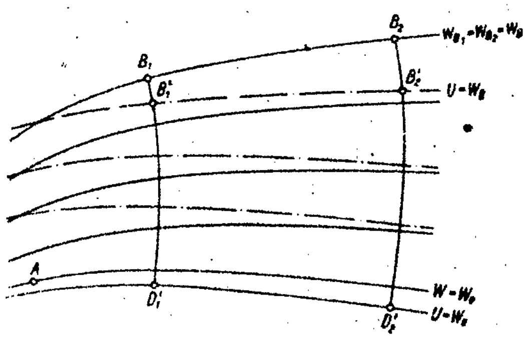

Figure 5

Points which lie on the same equipotential surface and simultaneously on the same parallel have the same standard elevations; for if B_1 and B_2 are two such points, their standard elevations will be determined by the same normal equipotential surface $U = W_{B_1} = W_{B_2} = W_B$ (Figure 5). The latter is, however, a surface of revolution and as such the points of a parallel are at the same distance on it from the reference surface and accordingly have the same normal gravity values $\gamma_{B_1} = \gamma_{B_2} = \gamma_B$. Therefore, for both points B_1 and B_2, we have $\gamma_m = \frac{1}{2}(\gamma_o + \gamma_B)$, and their standard elevations are the same. For the orthometric elevations this does not hold true, as here the g_m values can take on different dimensions. On the other hand, if the two points B_1 and B_2 of an equipotential surface lie on one meridian, then their standard elevations are different. For a difference of one degree in latitude, the difference in the normal gravity values amounts to approximately 90 mGal, as taken from the table of normal gravity values by Otto Meisser. If now the elevation H_{B_1} and H_{B_2} = 5,000 meters, then:

$$\bar{H}_{P_1} - \bar{H}_{P_2} = \frac{1}{\gamma_m^{P_1}}(W_0 - W) - \frac{1}{\gamma_m^{P_2}}(W_0 - W)$$
$$= \frac{W_0 - W_1}{\gamma_m^{P_1}} \frac{\gamma_m^{P_2} - \gamma_m^{P_1}}{\gamma_m^{P_2}} = \bar{H}_{P_1} \frac{\gamma_m^{P_2} - \gamma_m^{P_1}}{\gamma_m^{P_2}}$$
$$\sim 5000 \frac{90}{1000000} = 0{,}45 \text{ m}.$$

The quasi-geoid is not an equipotential surface, for equipotential surfaces, especially the geoid, are self-enclosed surfaces which do not intersect each other.

The quasi-geoid coincoides on the oceans with the geoid and has under the continents a terminal distance from the latter which does not vanish everywhere.

In any vicinity of the geoid there are equipotential surfaces, among them surely those having a smaller distance from the geoid than those of the quasi-geoid from the geoid. These equipotential surfaces are intersected by the quasi-geoid. Equipotential surfaces, however, do not intersect each other and therefore the quasi-geoid cannot be such a surface.

If the dimensions of the model earth, and thereby its outer normal gravity field, are changed, then the standard elevations are thereby changed, and also, on the basis of the changed physical surface of the earth, the quasi-geoid by its definition as a geometric locus. On the other hand, the geoid is firmly connected with the physical earth by the definition of Listing, and is changeable so long as the latter is not changed, as for its definition neither the dimensions of the model earth nor those of the physical earth were needed. It goes without saying that with a change in the dimensions which were used for an approximate calculation of the geoid, these approximation solutions change, but he surfaces of the Listing geoid, which are still inaccessible to us, remain untouched by such changes in dimensions. Once the dimensions of the model earth are determined, the quasi-geoid is uniquely fixed. Even if the two characteristics--that the quasi-geoid is not an equipotential surface and is dependent on the dimensions of the model earth--do not speak in favor of the quasi-geoid, it nevertheless has great advantages as compared to the geoid. These advantages lie, above all, in the fact that the quasi-geoid as an auxiliary surface fulfills the objective of an exact projection onto the reference surface of the elements of a geodetic grid measured on the physical surface of the earth, since it is the distance of the point of the earth's

surface measured along the normal plumb line through this point from the quasi-geoid as a standard elevation, and thereby its projection on the quasi-geoid, determined free of hypothesis and the distance of this projection from the reference ellipsoid known as the quasi-geoid elevation. For the geoid, the true orthometric elevation, as well as the geoidal part as an auxiliary sufrace, the distance of the geoid from the reference surface does not remain free of hypothesis, from which the superiority of the quasi-geoid over the geoid in geodesy is clearly seen.

(To be continued)

1907

EAST GERMANY

Geodesy and Cartography in the GDR

[The following is a translation of an article entitled "Das Vermessungs- und Kartenwesen in der Deutschen Demokratischen Republik" by H. Schilling, Chamber of Technology, Technical Director of the Geodesy and Cartography Administration, Berlin, published in Vermessungstechnik, Vol VII, No 10, October 1959, East Berlin, pages 265-268; CSO: 3942-N/4]

Concerning Social Development Since 1945

The tenth anniversary of the founding of the GDR is an opportunity for us to appreciate the results of the work done so far by the state geodesy and cartography system and also to observe it critically and draw final conclusions concerning its future large assignments. In doing so we must proceed from the fact that geodetic and cartographic achievements cannot be judged separately from the total political and economic development of the country.

When in 1945 fascism had plunged the German people deep into catastrophe, the democratic forces began to organize the reconstruction of our homeland. At the head of this reconstruction stood the workers' class, which was closed together with a firm unit of action, led by a Marxist party, which from the very beginning seized the intiative and indicated to the German people a clear road into the future. The elimination of the foundations of the economic power of German imperialism was inseparably connected with this reconstruction. Only by the destruction of the roots of German imperialism and militarism could a guarantee of a peaceful development and the erection of a democratic order be offered.

These lessons from the two world wars were learned only in the eastern part of Germany. Their consistent application signified the realization of the unity of the workers' class and the drive of economic and political reaction, which had many times plunged the German people into national catastrophe, and finally from every position of power. The workers took possession of the enterprises of the war criminals and

cartel rulers after they were transferred by law into the hands of the people. Thereby the entire basic materials industry became public property.

In the following years, a great revolutionary upheaval took place in the area of the GDR. The full responsibility for the organization of the economy and social life passed into the hands of the workers. Here we find the roots of the workers' and farmers' power. More and more workers learned that the decisive factor in improving life lay in increasing labor productivity, that only as much could be purchased as was produced. This developed a new socialist relationship toward work, and creative activity could unfold freely.

In the first stage, from 1945 to 1949, the tasks of the people's democratic revolution under the direction of the working class and its party were fulfilled, and the transition to the second stage took place. The Second Party Conference of the SED decreed in 1952 the planned construction of the foundations of socialism. The two German states, which originated as a result of the formation of a West German state, developed with contrasting social characters. In West Germany, now as earlier, the old forces of war and reaction, of the cartel rulers and junkers of the Bonn state apparatus prevail. In the GDR, which gave itself the task of ensuring the national interests of the German people, the foundation stone for a peaceful and democratic development structure was laid.

The observation of the present situation in Germany shows that our people's assembly and government have fulfilled the tasks transferred to them and have striven for a politics of peace. This was especially clear in the appearance of the GDR delegation at the Geneva Foreign Ministers' Conference. While the representatives of the Federated Republic were unmasked as foes of agreement, as enemies of the peaceful solution of the German problem, the GDR delegation represented the interests of the entire German people when they proposed the conclusion of a peace treaty with Germany and the transformation of West Berlin into a free, demilitarized city.

The development of our young republic can therefore fill us with pride. With this republic we are fighting for the preservation of our interests in assuring the peace and for a unified, peace-loving, and democratic Germany. To this end the decision of the Fifth Party Conference reads: "Our worker

and farmer regime works for the guaranteeing of peace and the resurrection of German unity on a peaceful, democratic basis; it steadily improves the well-being of the people through progressive development of the productive forces; it organizes the building of socialism; it develops everywhere the national culture and the cultural life of the masses, secures the achievements of the workers, and guarantees the protection of the political power and freedom of the state, its independence, and security. These tasks will be all the more rapidly fulfilled as the consciousness of the masses is more strongly fixed on these tasks and as the masses themselves more actively participate in them."

The role of the intelligentsia in our state has special significance. The securing of the maximum satisfaction of the constantly growing material and cultural needs of our entire society requires, according to the basic law of socialism, a constant perfecting of socialist production based on the most highly developed technology. Here the development and the introduction of the most modern sciences in all areas and their constant further development is required. Therefore, the intelligentsia supports and furthers our state--and, to be sure, not for tactical reasons; this furtherance corresponds to the essence of our state.

The Fifth Party Conference has placed large tasks before us. The national economy is to be developed to the point where the per-capita consumption of the workers of all important necessities of life and consumer goods will be higher by 1961 than the per-capita consumption of the entire population of West Germany. Industrial production will be increased by 1965 to 188 percent. During the same period in which the West Germany imperialists want to bring about atomic armament, our republic is giving all workers long-range plans for peace, well-being, and happiness.

Goal Planning of Geodesy and Cartography in the GDR

Let us glance backward once more at the tenth anniversary of our republic. What consequences and final results came about after 1945 in geodesy and cartography? It was already determined that the development of our field could not be separated from the all-embracing social development. On the contrary, the building of geodesy and cartography was brought about in the middle of the upheaval process which has taken place since 1945 in the GDR area. This calls forth the

question of how each one of us has contributed through his personal performance in actively supporting the organs of the state in their work of improving the lot of the workers.

Geodesy and cartography was earlier closely connected with every state apparatus. The geodetic and cartographic services of the fascist state received, among other things, the assignment of cartographically well preparing the overthrow of foreign countries, as can be read in various documents of the former Reichsamt for Ordnance Survey. Our state has provided geodesy and cartography with basically different assignments. In accordance with the new socialist social order, geodesy and cartography were given the goal of serving peace and of maximally satisfying the requirements of the national economy. How, on the other hand, is one to evaluate the fact that according to an article in a West German technical journal the "care and guardianship of the Reich maps was transferred outside of the jurisdiction of the basic law to an institution maintained by the Bund." This political goal is also completely clear. How far do these "Reich map works" go? They no longer need to be cared for and guarded; this means doing a disservice to peace. This is quite apart from the fact that they have become historical and have been superseded by modern map works.

Here we should say a few words of appreciation regarding the excellent achievements of the geodesists and cartographers of the People's Republic of Poland and the Czechoslovak Republic, and of course the geodesists and cartographers of the entire socialist camp. We feel ourselves joined with them in the principle of mutual regard and trust in the friendliest and heartiest manner. It is known that geodesy and cartography are sciences especially suited to binding peoples together. A decisive condition is, however, the complete recognition and regard of the sovereignty of other states. The "care and guardianship" of the maps of foreign territories is decidedly not planned to effect the joining of nations together.

Tasks of Geodesy and Cartography in the GDR

In the GDR the main task for geodesy and cartography is derived from the long-range plans for the building of sociali For surveying engineering, this means the execution of engine ing-geodetical work and the production of large-scale plans for the various branches of the national economy. In the field

of geodesy, the trigonometric, leveling, and gravimetric fixed point fields are to be constantly perfected and currently maintained. The job of topography consists in producing 1:10,000 scale maps of entire state areas; industrial and others of concentration will be represented on 1:5,000 scale maps.

The task of topographical cartography consists of the cartographic and technical reproduction processing of topographical field originals of basic scales of 1:5,000 and 1:10,000, as well as in the production of derived series on scales of 1:25,000, 1:50,000, 1:100,000, 1:200,000, 1:500,000 and 1:1,000,000, and in printing map works. Another important task for topography and topographical cartography is the constant current maintainence of the entire map works.

The close connection of geodesy, topography, and topographic cartography with geographic cartography and the significance of the products of geographic cartography for the various branches and spheres of our social life, especially for the formation of a socialist consciousness, requires the organizational union of geographical cartography with the state geodesy and cartography system.

The task of geographic cartography consists of the production of geographic and thematic maps as well as the production of atlases for the national education system, the national economy, and science. The points of concentration are a national atlas of the GDR; planning atlases for the GDR and the individual bezirks; school atlases and wall maps; thematic maps for industry, forestry, agriculture, construction, tranport, trade, traffic, and administration; special atlases for certain professional fields; general educational and political maps; and, finally, travel maps and city plans.

These briefly summarized main tasks for geodesy and cartography have resulted especially from the decisions of the Fifth Party Conference of the SED. They are aimed at the fulfillment of the main economic task and will serve the victory of socialism.

In Competition with Capitalism--For the Victory of Socialism

1. The peaceful competition of socialism with capitalism is today drawn out into the economic sphere. The basic problem of the socialist countries is to gain the maximum of

time in this economic competition. Therefore, a rapid pace in the development of the individual sectors of the national economy is to be guaranteed in order to visibly surpass capitalism in the historically shortest time possible for everyone. This is an auspicious but completely real perspective. For example, the share of the socialism camp in the world's industrial production will amount to more than 50 percent in 1965.

Just as the Soviet Union has given itself the task of catching up with and overtaking the USA in per-capita production, the GDR has given itself the task of so increasing the development of production in industry and agriculture by applying the most advanced science and technology that the standard of living of the people of the GDR by the end of 1961 will reach and partly surpass that of West Germany. The fulfillment of the main economic task decided on by the Fifth Party Conference of the SED also requires in geodesy and cartography the mobilization of all forces in order to emphatically prove the over-all superiority of the socialist order in the GDR over the rule of the imperialist forces in the Bonn state. To fulfill these life assignments we have set concrete goals for ourselves in our economic plans. The successes achieved through the efforts of our workers in the Second Five-Year Plan require the establishment of new plan goals. At the same time our planning now comprises a longer time period. The Seven-Year plan is the beginning of the transition to plans of a longer range and scope.

The working our of our Seven-Year Plan will lead to maximum results only when the rich experience of workers, engineers, scientists, and the entire populace is fully considered. The plan discussion under the slogan "Plan together, work together, govern together" is an important component and an expression of our living democracy.

2. We are also working according to long-range plans for the first time in geodesy and cartography. The Geodesy and Cartography Administration has published the themes for the Seven-Year Plan in geodesy and cartography. The great discussion was introduced with a central technical and scientific conference. The task of this conference was to discuss an increase in labor productivity and an improvement in quality in creating topographical map works. In the foreground stands the introduction of the most rational technological processes under maximum utilization of available technical equipment. The discussion was continued in the technical and

economic conferences in the services subordinate to the VVK [Geodesy and Cartography Administration]. At the same time the tasks for the plan year 1960 and our tasks in the Seven-Year Plan were discussed in all brigades. Thus the opportunity was given to elucidate to all coworkers the connections between politics and economics as well as the lawfulness of socialist construction. The inclusion of the workers in the planning and management of the economy and the state is of great political significance. A pre-evaluation of the plan discussion shows us with what high political consciousness of responsibility our workers, engineers, and cartographers made use of advice given on the plan assignments. This is also shown in the many creative proposals and ideas which entered into the plan goals.

3. Such an activity is possible only on the basis of the social relationships created in our republic, because the work of each creative worker has a new and sensible content. In regard to production, the basic contradiction between the social character of production and the private capital form heightens the conversion of the latter to the former. With the development and establishment of the socialist method of production, the socialist content of the work is formed. Through the fact that workers are made conscious of their new relationships with each other and with their means of production, they will take an ever more active part in socialist construction and will produce good work for our common socialist efforts.

In the past "socialist work brigades" were formed. They have set their goal to work, learn, and live. The socialist work association has developed in the battle for technical progress; the relationship of trust between workers and intelligentsia has been firmly established.

4. Work performed in a new socialist manner, work performed in socialist collectives for a socialist society--that is the new factor which has developed in our country. This development process transfers to the state directors a high obligation and responsibility and requires new forms of management capability. Thus one of the main tasks of the VVK consists in guaranteeing the greatest possible participation of all coworkers in the management and control of the services and offices for geodetic engineering. In our services and offices we have an abundant network of forms and methods which assure the participation of coworkers in the management of production. Such forms are the activists and competition

movement, production conferences, enterprise collective agreements, norm work, a suggestion and inventions system, etc. A no less important task in management activity is socialist educational work. Political and ideological education work connected with practice will help to form closer new relationships of coworkers with socialist property and the socialist state. The VVK will be able to further improve its management capability by transferring more independence and responsibility to the directors of services, offices, and enterprises. They can thereby concentrate more attention on solving basic problems.

5. After the goal planning and assignments in geodesy and cartography are made completely clear, we will then decide about the result of organization. The structure was subjected to various alterations as it had to be constantly adapted to the new tasks, which were becoming ever greater. The structure built according to the principle of democratic centralism suits the tasks in geodesy and cartography for the next few years. The tasks of land surveying have been transferred to the topographical services and to the geodetic and cartographic service. The geodetic and engineering work will be carried out in the Office for Engineering Surveying, and the assignments in geographic cartography, including wall maps, will be carried out chiefly in the Hermann Hack VEB in Gotha, and in the Land Map Publishing VEB in Berlin.

Geodetic and cartographic work is financed according to the principles of economic accounting procedures; therefore, the unity of technology and economics must be observed especially by managerial coworkers. Each technical measure has a financial effect. The task of the engineer is to obtain the maximum work output with the smallest possible expenditure of manpower and materials. Without knowledge an engineer cannot do justice to his assignments.

6. All geodetic and cartographic work processes are based on the principle of planning and economy. Technical projects are worked out for production assignments. These projects for any given work area comprise assignments for several years and form the foundations for planning. An important principle for working out technical projects is the complex observation of all work areas in order to guarantee a continuous work flow. Another principle is the application of the latest scientific knowledge in geodetic science and practice. The results in geodesy and cartography so far do full justice to these requirements; this refers especially to trigonometric and

leveling work and to the production of map works. As an example, we may point to the system developed for scientific editing work in the production process for topographical maps. The editorial work has essentially improved the quality of the topographical maps. The application of the results of research in regard to legal generalization will make map production still more scientific.

Higher Productivity Through Socialist Reconstruction

The planned high growth rate in the production of geodetic and cartographic materials by 1965 requires that all possibilities of increasing labor productivity be utilized as well as all the advantages of the socialist social order and the struggle for technical and scientific progress. The content of socialist reconstruction consists of a more rational organization of production on the basis of the highest level of technology and science and the full application of the creative initiative of the workers. The following points of concentration are foremost in geodesy and cartography:

a) the introduction of the most rational technological process;
b) maximum utilization of available technical equipment;
c) expansion of the technical base;
d) constant technological supplementation and perfection;
e) more rational utilization of working time;
f) general rationalization of the entire work flow;
g) an exact measurement of expenditures and results comparisons;
h) worker qualifications.

The complex character of these tasks requires that scientists, engineers, activists, economists, and workers master in common the reconstruction in close socialist cooperation. Of outstanding significance for increasing labor productivity in geodesy and cartography is the introduction of photogrammetry. The reconstruction in photogrammetry must encompass:

a) technical equipment for aerial photography;
b) technical equipment for aerial photograph plotting;
c) improved personnel qualitidations;

in order to ensure maximum satisfaction of the needs of the economy and land surveying for photogrammetric materials.

Furthermore, the main attention must be directed to savings in field work. This requires the application of already known methods and the development of new ones. Local work, for example, can be decreased by expanding aero-triangulation series and by data flights made simultaneously with detail flights using photo cameras of different focal lengths. On the other hand, photogrammetric plotting of the relief in a less suitable terrain while maintaining appropriate accuracy has so far been unsatisfactorily carried out. According to the terrain structure of the GDR at the present time, only 30 percent of the area can be plotted with stereo-cartographic equipment. This amount favors a change in stereo-plotting. This requirement must also be expanded to forest areas.

In cartography, efforts must be concentrated on the further perfection of the layer or seam engraving method and the reproduction technique. Of special importance is the mechanization of the work processes in all areas of geodesy and cartography. Here all possibilities are far from being exhausted.

The realization of the all-embracing reconstruction measures requires the planned employment of all forces and a clear orientation of all to the main tasks. We must not split our forces, for then we lose time. We gain time when we concentrate them on definite projects. The assignment for each service, for each research center, and for each engineer is to be thoroughly worked out. Each individual must know exactly what he has to do at his place of work in fulfilling the main task. Science and technology are concentrated completely on fulfilling economic assignments. The Central Work Circle for Geodesy, Photogrammetry, and Cartography carries a large responsibility. Scientific results must very quickly be put into practice.

There is no doubt that, by building on the successes of the past years, we can fulfill the tasks ahead of us. Let us develop under the leadership of the party of the working class, in close cooperation with our worker and farmer state, a great initiative for the victory of socialism in the German Democratic Republic!

1907

EAST GERMANY

Development of the Potsdam Geodetic Institute After 1945

[The following is a translation of an article entitled "Die Entwicklung des Geodaetischen Instituts Potsdam nach 1945" by Prof Dr K. Reicheneder, Potsdam, published in Vermessungstechnik, Vol VII, No 10, October 1959, East Berlin, pages 269-270; CSO: 3942-N/5]

The Potsdam Institute has been since its founding closely connected with the middle European grade measurement initiated in 1862 by Bayer. This international union, which later expanded by stages into a European grade measurement and to international earth surveying, had set itself the goal of carrying out a triangulation between the Caspian Sea and the Atlantic Ocean. An institution was created for the broad work necessary for this in the area of the Prussian state of that time, which later also had the general task of improving the theory and practice of earth and land surveying--i.e., the direction of higher geodesy.

This institute, which had already begun its activity in 1868 but which acquired a solid organization only on 1 January 1870, was originally quartered in several private houses in Berlin. By the Statute of 1877 it consisted of a president, four department chiefs, four permanent assistants, four auxiliary assistants, and the required auxiliary personnel. The present service building on the Telegrafenberg in Potsdan was occupied in 1892.

The extraordinary capabilities of Friedrich-Robert Helmert, its director at that time, and the fact that the Central Office of International Earth Surveying was by statute firmly connected with the Potsdam Geodetic Institute, brought to the latter an unexpected upswing and made it a Mecca for geodesists. This heyday was rudely interrupted by the First World War. The Versailles Treaty of 1919 excluded Germany from all international organizations. The Central Office for International Earth Surveying and the Office of the International Latitude Service had to cease their activities in the Potsdam Institute. Between the two world wars, therefore,

it could only play a modest role on the international level, but it was not inactive. During that period the first quartz clocks were built in the institute, thereby laying the foundation stone for the present significance of its time service.

The general collapse in 1945 also did not spare the institute, which had considerable damage to buildings and scientific equipment to bemoan. In 1946 it was incorporated into the German Academy of Sciences in Berlin. Scientific work in the early years thereafter was hindered by shortages in material, instruments, and personnel. The number of scientists had sunk to four in 1952. In the meantime, however, our young republic had so established itself that the government could bring about the renovation of geodetic foundations. Also, the significance of higher geodesy was given its due by the Decree of the Council of Ministers of 18 March 1955; the work of the Potsdam Geodetic Institute was furthered in keeping with its international significance. The reconstruction progressed rapidly under the solid support of the German Academy of Sciences. Building damage was removed, valuable equipment procured, and new personnel employed. Today the institute has 19 academically trained personnel among its total of 70 employees.

Although in the early postwar years only theoretical investigations could be carried out in addition to the necessary maintainance of the time service, today active life is unfolding in all departments. The motto of Leibniz, the founder of our instititute, "theoria cum praxi," which has very great significance in geodesy, was the guidline. The research assignments of the institute, which cannot be surveyed here individually, have developed for the most part directly from the requirements of land surveying or the time service, but the national needs have always stood in the foreground.

This concerns the investigations concluded in our mathematics department on the compensation of triangle nets according to the Eggert method and in the setting up of formulae for determining geoid undulations and plumb [line] deviations from free-air anomalies, especially because of their applicability in mountainous regions, as well as for the calculated table for solving the main geodetic task. The nomograms will answer a very urgent need; these will round off the modern solution of the astronomical and gravimetrical leveling worked out by Dr Arnold.

The Department of Practical Geodesy has not only established its reputation through the rehabilitation of the Potsdam standardization base with erection of a new gauge building and its use in base measurements; above all, it has excelled in its large-scale investigations on the thermal behavior of invar wires, which are connected with the determination of numerous coefficients of thermal expansion. An ingenious temperature compensation for optical section measurement was thought out and thoroughly tested. A device for direct section measurement, which guarantees an accuracy of 4×10^{-5}, has been developed for distances up to 500 meters and has already proved successful in practical work in the Northern Surveying Service.

The interference comparator developed in the physics department is to be used primarily for the absolute standardization of 24-meter wires. After initial difficulties, we were able to put together usable pendulum devices and carry out successful observations at the Bergen, Ilmenau, and Bautzen stations, which serve to maintain the level in the gravimetrical ground grid in the GDR. Long investigations on the magnetic behavior of the invar pendulum were connected with this.

A measurement of the Potsdam-Sofia difference in gravity carried out last year is still being plotted. The new determination of the absolute gravity in Potsdam takes up an especially large amount of space in our research work. This is being furthered on a large scale by our government, particularly as Potsdam is the international reference point of gravity.

A new type of method with reversible pendulums has been thought out, and the smaller apparatus has already been built in the Potsdam Geodetic Institute. The two 25-centimeter pendulums illustrated here (Photo 1) represent a top product in the precision machinery and optics production of the Carl Zeiss VEB in Jena, which carried out the precision grinding work. In this connection also, an electronic device for pendulum time measurement was developed which permits the observation and plotting time for pendulum measurements to be essentially decreased. We hope that the ocean or lake gravimeter (Seegravimeter) developed by Prof Haalck, which is currently being tested, will have great significance for geodesy and practical geophysics.

The determinations of longitude, carried out in the last few years by coworkers of the astronomy department between Potsdam and the land centers of the neighboring republics of Czechoslovakia, Poland, and Hungary, are of basic significance for the land grid of the GDR. The improvement in the time service has contributed to the success of the investigations on the influence of the wind in time determinations. The tasks of the International Geophysical Year acted as a strong stimulus and placed large requirements on astronomical observers. The number of time determinations increased more than twofold. The institute entered the latitude service and was able to obtain excellent results, thanks to the Danjon astrolabe, which was granted by the government. Many members of the institute were inspired by sputnik observations, not fearing the personal sacrifices connected with this. Even a theodolite with graduated circle registering could be put together with relatively simple means.

The time service units were modernized, an accumulator basement was installed, and an emergency current aggregate was set up which charges the clock units in case of a power failure. We were also successful in recent years in making the time service of the institute available to all interested parties within and outside of the GDR by means of a time duration signal beamed out over the Nauen transmitting station (Photo 2). This is controlled by the institute in the same manner as the short time signal heard on the democratic radio [GDR radio?] around 07:00 and 13:00 hours. Our time service, moreover, supplies the second contacts over transmission lines for the synchronization of the speaking clock in the telephone and the standard frequency of 1,000 Hertz for consumers in science, industry, and commerce. In addition, other frequencies are supplied to the Babelsberg Observatory and the Potsdam Branch of the DAMG [not identified].

The time service of the Potsdam Geodetic Institute has a top position among the time services of the entire world and has joined in international cooperation. Lasting connections exist with the Committee for Standardization, Measurement, and Measuring Equipment in Moscow, with the Bureau International de l'Heure, Paris, with the International Latitude Service in Turin, with the Poltava Observatory in the USSR, and the Neuchatel Observatory in Switzerland, and, in regard to star occultations, also with Greenwich Observatory.

The present significance of the Potsdam Geodetic Institute is still underlined by the fact that many of its coworkers

participate in an advisory capacity in special committees and work circles. A documentation center for higher geodesy was set up in the instititute.

The institute regarded it as a self-understood obligation to make its personnel and material capacity available when the state geodetical system in 1953 saw new assignments coming in the field and built up a geodetic service. A large number of personnel, especially of astronomical observors, were trained in the institute, and the institute workshop for the production of smaller equipment was drawn upon [for some of this training]. The good cooperation with the geodetic service and the surveying services will also be quite fruitful in the future.

A picture of the institute, its development, and its economic significance in the present has been presented here. The rich successes were only possible thanks to the bread advance of the sciences in the GDR. We were able to send our young scientists for study abroad, to expand observational areas, and to modernize and essentially expand instrumental equipment. A modern workshop building with garages, a lecture hall, and installations for the employees was ready to be occupied this year. It remains for me only to thank all those who contributed to the success of this work.

Photo Captions

Photo 1. Experimental Work with the 25-Centimeter Reversible Pendulum for the New Determination of Absolute Gravity.

Photo 2. Receiver and Quartz Clock for Controlling the Time Duration Signal DIZ.

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EAST GERMANY

Principles and Trend of Development of Geodetic and Cartographic Research in the GDR

[The following is a translation of an article entitled "Grundzuege und Entwicklungsrichtung der geodaetischen und kartographischen Forschung in der DDR" by Prof Dr Engr W. Zill, Chamber of Technology, Dresden Advanced Technical School, published in Vermessungstechnik, Vol VII, No 10, October 1959, East Berlin, pages 271-273; CSO: 3942-N/6]

The investigation of scientific foundations is a prerequisite for effective technical progress and for the development of entirely new methods. When an assignment for a specific purpose is set up, it can then only be fulfilled or better and more rapidly carried out when the problem on which the entire process is based, and also the individual areas of the practical execution, are scientifically conceived and explored. The more basically and broadly this takes place, the closer one comes to the optimum solution. Therefore, a differentiation is made between basic research and the application of its results for the fulfillment of determined tasks, called objective research. In order to give more rapid and effective aid to practice, agreements should be concluded between industry and research centers, in which the mutual obligations of each to the other are laid down. By this research through agreement, the connection between theory and practice will be established and the rapid introduction of the results of research into production assured.

Research work of broad scope has also been under way in the area of geodesy and cartography in Germany since the beginning of the technical development. The results in theory and practice, and in the design and construction of instruments have contributed essentially to the development of geodesy and cartography in all special fields. In the last few decades, however, as an effect of two imperialistic wars, we have experienced a certain lag, which we must now make up.

At the present time the following centers in the GDR are concerned with research and development work in the field of geodesy, photogrammetry, and cartography:

The Geodetic Institute in Potsdam is the center of traditional basic research. The directors and coworkers of this research institute of the German Academy of Sciences have for a long time been counted among the most significant scholars in these special fields. We can recall Helmert and Eggert, the old masters of German geodesy, to name a few. In research work in Potsdam the emphasis lies in the area of higher geodesy, gravimetry, and geodetical astronomy. In the last few years problems in practical geodesy have also been taken up in the research program of the Potsdam institute.

The educational institutes of the advanced schools carry out research in their special fields of higher geodesy and geodetic astronomy, photogrammetry, practical land surveying, geodesy, mining geodesy, and cartography, in addition to their primary function of training prospective specialists. These are the Dresden Advanced Technical School, the Freiberg Mining Academy, and the Advanced Schools for Construction Engineering in Leipzig, Cottbus, and Weimar--to name a few. The Engineering School for Geodesy and Cartography should also, to ensure a good composition of their faculty, be in a position to take on research work in connection with practice.

The research centers formed by the Geodetic and Cartography Administration have gained great significance in the geodetic and cartographic service. Here all those theoretical and practical problems which crop up in preparing and executing the large tasks of geodesy and cartography are to be directly and unhesitatingly solved. An appropriate strengthening of these centers and their close cooperation with the offices for inventions in the services and enterprises is to be striven for.

Moreover, the research and development centers of those enterprises which produce the instruments and equipment for all geodetic, photogrammetric, and cartographic work are occupying themselves not only with development and design but also, above and beyond this, to a large degree with scientific principles and partly even with methods of application. This concerns not only the enterprises of the precision instruments and optics industry but also those of many other industrial branches--for example, paper production, synthetic film, photographic materials, printing dyes, etc. The

quality of the work supplied by geodesists and cartographers is very greatly dependent on the quality of the auxiliary materials available, which at the same time also essentially influences labor productivity. We must therefore attribute great significance to the development and research work of the supplier enterprises.

This current research and development work, which is carried on separately at different points, needs appropriate coordination if the economically most important tasks are to be fulfilled with the smallest amount of time expenditure, work duplication is to be avoided, and the greatest economic profit is to be achieved.

Therefore in 1957 the government of the GDR formed a research council of 45 members, which sets up the long-range plans in natural scientific and technical research. It also brings the assignements resulting from this into agreement with the economic plan and the economic requirements as well as with the available research capacities in the republic. The measures for the introduction of the most advanced techniques in all fields is thereby centrally controlled and coordinated. In carrying out these assignments, the Central Bureau for Research and Technology has been joined to the research council. The plan for research and technology set up through common work is then confirmed by the research council as a component of the economic plan. The scientists themselves decide how the means for scientific research and technical development made available by the state are to be individually applied.

As not all special fields can be represented by members of the research council in all details, central work circles have been formed for support. Thus, in June 1958, the Central Work Circle for Geodesy, Photogrammetry, and Cartography was established under the chairmanship of Prof Dr Zill of the Dresden Advanced Technical School. The circle consists of 15 members, who belong permanently to geodetic and related institutions. The individual problems are individually discussed in the six work groups, which are each under the direction of a member of the work circle. In the composition of the work groups, which consist of 10 to 12 members each, great value is placed on the representatives who are in practice. The results achieved from the discussions of the work groups are coordinated in the work circle.

All research work connected with the development and designing of instruments and equipment are handled in the "optical equipment" central work circle. This circle includes a special "mining geodesy and surveying" work group under the direction of Dr Rueger of the Freiberg Mining Academy. In this [group] the representatives of the instrument producing industry and their research and development centers, together with the scientists and practicing specialists, are striving to further establish the work reputation of our geodetic instruments and to achieve a jump ahead in development. This work group had formed earlier its own work circle and has already been doing successful work for many years.

There are connections among the work circles, of which naturally those between the work circle for geodesy, photogrammetry, and cartography and that for optical equipment are the closest. Thus the plans set up by the mining geodesy and surveying work group are discussed before being approved in the work circle for geodesy, photogrammetry, and cartography. It is therefore guaranteed that the development of instruments and equipment corresponds to the requirements of practice.

Research projects which touch the fields of other work circles are submitted to them for their opinion. If an assignment falls directly into their sphere of work, they take it over for processing if appropriate research facilities are free. Complex assignments which fall into the areas of several work circles and are of exceptional economic significance can lead to the formation of research associations which are directly subordinate to the research council. For example, such research associations have been formed for the processing of problems in electrical section measurement and in regard to electronic automatic calculators. Socialist technical association work finds its full effectiveness in these associations.

The close connection with the Chamber of Technology plays an important role in all advisory organs. The ideas developed directly in production in enterprises for improving work processes and work means are reported by members in their work groups who are at the same time members of the Chamber of Technology. After appropriate consultation and testing, the road to their realization is cleared by the work circle.

A not unimportant function of the work circle is the control of the work of individual research and development centers. This control refers to maintenance of the established plans in regard to the timely progress of the work as well as to a criticism of the results obtained. The work circle should be more concerned than previously with the financing of research work in order to see that the great effect is obtained with the smallest amount of means. In addition a very important task consists in carrying over the results of research into practice. The work circle is not only to test and further direct the results of research but is also to see that new methods which have been recognized as more economical than those applied thus far are actually applied in enterprises and service centers.

The following main trends can be mentioned for the entire research and development work in the field of geodesy, photogrammetry, and cartography:

The new determination of absolute gravity in Potsdam stands in the foreground in the area of basic research. This is to be carried out with the help of reversible pendulums, whereby special attention is being devoted to knife-edge suspensions (Schneidenlagerung). Moreover, various problems in higher geodesy are being worked on which are concerned with the determination of the form of the geoid. Longitude and latitude determinations within the framework of the International Geophysical Year in Potsdam and Dresden constitute an important contribution of the GDR to this large-scale international research program. Other work is concerned with the investigation and improvement of quartz clocks and chronographs. A method for the photometric determination of shadow transit in solar eclipses for the exact determination of great distances on the surface of the earth independently of the plumb deviation is in the development stage. In photogrammetry the introduction of electronic masuring elements in taking and plotting aerial photographs is being investigated. The use of aerial photograph measurement, especially for tasks of regional and town planning as well as for the new arrangement of ground parcels, is a point of concentration of photogrammetric work in regard to the economic uses connected with it. In cartography, in addition to the basic investigations relating to the layer or seam engraving process, work on the system of generalization in regard to the derivative of series scales for maps is being given priority.

In practical research the problems being predominantly worked on are those which appear currently in carrying out practical work in the services and in the offices for surveying engineering. This concerns mainly smaller jobs which must be quickly completed. Here a still close cooperation between research centers and practice, as well as greater mobility on both sides, is required. In the foreground stand the investigations which contribute to the mechanization of the work process in geodesy, photogrammetry, and cartography. The greatest successes have been achieved here in the areas of cartography and photogrammetry. The fruitful cooperation between theory and practice in the work groups of the central work circle will also lead to the necessary intensification.

Outstanding results have been obtained in the past ten years, especially by the Carl Zeiss VEB in Jena, but also in other enterprises in the development and designing of geodetic and photogrammetric equipment. The theodolites, levels, and tachymeters developed there are among the top production of the world in regard to their quality. However, in several areas new developments lag behind the world level. We still do not have available leveling instruments with automatically horizonted sight lines, compensators for the altitude index on vertical circles, a self-reducing alidade, and a precision tachymeter with a vertical rod. We still lack photogrammetric plotting devices II and III. Rapid and fruitful work is expected from the research association for the areas of electro-optical and electromagnetic section measurement. The development of an electronic small automatic calculating machine for geodetic purposes is to be greatly accelerated, as this equipment could be employed in many other industrial branches to great advantage. All in all, the development of instruments is being carried out from the following point of view: decreasing the weight of instruments and increasing the measuring speed with a simultaneous increase in the accuracy of measurements.

More use is to be made of research by agreement or contract. The research center takes over rigidly fixed contracts, which must be processed at a fixed expenditure in a set period of time. The financing then is the task of the contractor, who is interested in applying the results directly in production in order to decrease costs and improve the quality of products.

The coordination, already in progress for one year, of research and development assignments through the Central Work Circle for Geodesy, Photogrammetry, and Cartography will undoubtedly lead to concentration on the projects most important for the national economy. The results will be more rapidly carried into practice and the assignments in geodetics and cartography in the GDR will be more effectively supported.

1907

EAST GERMANY

Ten Years of Activity of the "Chamber of Technology" in Surveying and Cartography in the GDR

[The following is a translation of an article entitled "Zehn Jahre "Kammer der Technik" Arbeit im Vermessungs- und Kartenwesen der Deutschen Demokratischen Republik" by Dipl Engr A. Zappe, Chamber of Technology, Chairman of the Special Department for Geodesy, Berlin, published in Vermessungstechnik, Vol VII, No 10, October 1959, East Gerlin, pages 287-288; CSO: 3942-N/8]

The gift table for the tenth anniversary of our republic, the first worker and farmer state, has been covered with enthusiasm by all workers. Geodesy and cartography personnel are not absent among them. When we look back today we can state that the members of the Chamber of Technology have also contributed to the successes achieved in geodesy and cartography in the GDR.

When, after the collapse in 1945, the workers organized into the Free German Trade Union Alliance [FDGB--Freie Deutsche Gewerkschaftsbund] and under the political leadership of the unified workers' party proceeded to overcome the indescribable damage and the need which the fascist military war had brought to the fatherland, and built up a new social life supported by the will to freedom, there were also hours in which the progressive, peace-loving technical intelligentsia organized into voluntary associational work.

The allied executive committee of the FDGB has fully recognized the significance of the initiative of Engr Max Guenther, the present Vice President of the Chamber of Technology, and a large number of natural scientists, engineers, and technicians has given it every support. The leaders of the working class, Wilhelm Pieck and Walter Ulbricht, had already at that time given a high appraisal of the creative work of the technical intelligentsia for the humanistic development of mankind as had never before been given in Germany. What significance the representatives of the the first socialist state, the Soviet Union, attributed to this initiative is seen from a letter of the then Soviet military administration of 8 May 1946 to the FDGB:

"The zone administration of the FDGB will be herewith permitted to set up a chamber of technology from the trade unions and to publish a monthly periodical Die Technik, as an organ of the Chamber of Technology."

Thus was the KDT (Kammer der Technik), which counts over 80,000 members, born. In accordance with the statutes of the first main committee, the KDT was divided regionally into regional chambers and by specialities into special departments [FA+-Fachabteilungen]. The Special Department for Construction Engineering, which later also incorporated the professional personnel in geodesy, was one of the first formed in 1947.

Everywhere in the country geodetic personnel joined into voluntary associations, into specialist and work committees. The most important centers lay in Dresden, Leipzig, Schwerin, Jena, and Erfurt. In 1950 all these units of organized, technical association work were successful in combining into a central special geodetic committee and in annexing itself to the then Special Department for Construction Engineering in the KDT. The present president of the KDT, Prof Peschel, had a decisive role in intitiating this step. He was also elected the first chairman of this committee.

In looking back, we must characterize the then beginning period of KDT work in geodesy as a period of reflection and clarification. Most of the progessional personnel were employed in carrying out the democratic land reform and thus spurred on the association-forming activities of the workers. The privilege system, which was highly developed under the old surveying system, was eliminated by the democratic reforms, and progressive and revised concepts were put forth one after the other in the special committees. The initiative of the specialist committee was directed to the employment of surveying specialists in the reconstruction of our fatherland, to the popularization of the many and important connections of our specialized technical work with the total economic and cultural development. An essential content of the meetings and conferences was also the qualifications of workers and the disclosure of the technical opportunities inate in geodesy. Efforts were also made toward further developing the system of geodesy and cartography, which had been so misused by fascism, and the state geodetic and cartographic work, which had been broken up and neglected to the point at which it existed before it was utilized for fascist war preparations. Our KDT work at that time consisted of

holding a series of lectures and several large conferences. It was also expressed in the periodical Vermessungstechnik, which appeared since 1952 as a supplement and then from May 1953 as an independent periodical of the KDT. In the meantime, Vermessungstechnik has developed into a noteworthy technical organ.

About 500 professional colleagues took part at the first large conference of our specialist committee. This conference was significant because the then state secretary Warnke was able to state at it that, in the construction of the state apparatus, the economic significance of geodesy and cartography was recognized and that it had obtained a firm place in the Ministry of the Interior. Representatives of the State Planning Commission and the Ministry of Construction made public the economic goals for which geodesy and cartography are to fulfill great tasks, create planning data, and work effectively and creatively in realizing projects.

This conference essentially contributed to stimulating voluntary technical association work. For example, 170 activities with about 5,000 participants were carried out in 1952 in Mecklenburg. Of significance also were the so-called regional conferences. On the occasion of such conferences in Schwerin and Goerlitz, the Special Geodesy Committee appeared before the public with an exhibit of "social and land maps." We succeeded well at that time in concretely representing the connections between the work of the geodesists and cartographers and the social, political, and cultural development through the inspired cooperation many KDT members. At that time, however, we still did not succeed in making a basic analysis and starting further development of our work results.

There were still other efforts in KDT work to provide a new blossoming for the geodesy and cartography of our young republic. At the conference in Cottbus in 1952, efforts were made to obtain the best work organization and technology for the production of a topographical detail map and for connecting scientific and research work in the academy institute with practical needs. In Gotha in 1953 the necessary foundations for a uniform, scientifically based land surveying system were illuminated for the first time, and the position and processing of the astronomical and geodetic network of the Soviet Union was compared with corresponding work in the USA and Western Europe.

The active members have not become tired of pointing up the possibilities which exist in technology for increasing labor productivity. Today it is completely understood what was discussed and worked out in many countries of the FA up to about 1952 for setting polat photographic work into motion. We should also mention here the great understanding that the chair of photogrammetry and the Geodesy and Cartography Administration have brought to the work plans of the FA. The two short lecture courses on photogrammetry at the [Dresden] Advanced Technical School (1953 and 1954), for example, were the fruits of this cooperation.

The central state surveying conference held in Leipzig in 1954 was of decisive significance in the development of geodesy and cartography in our republic. At that time the new structure of our state was already established, the various regions were incorporated into the new bezirks, and all prerequisites for a uniform direction of the state surveying system were guaranteed. This conference showed clearly that:

1) the geodetic and cartographic system of our young republic lay firmly in the hands of progressive personnel and had a responsible top place in the worker and farmer government in the Ministry of the Interior;

2) the coworkers in geodesy and cartography had to take a big step forward in order not to remain behind the scientific, economic, and technical development of the other sectors of our national economy.

Since then, the work of the Geodesy FA has oriented itself more and more toward the points of concentration that were worked out. The striving for ideological clarity was connected with efforts made for scientific and technical progress. The distribution of assignments in KDT work were increasingly brought into agreement with the structure, the work organization, and the entire work content of a uniform system of geodesy and cartography under the socialist reconstruction in our fatherland. In the KDT also, the initiative of the members was more and more recognized as a part of the struggle for peace. Progress in the qualification of members, the study and evaluation of the achievements of professional colleagues in the Soviet Union and in the friendly people's democracies, and our own new findings which came as a result of intensive thinking through of the work process, and large and small improvements in technology and work organization became conscious contributions to fulfill-

ing the established plans and to strengthening our worker and farmer regime. The small jobs in the KDT were switched over more and more to the operational sections of the large service centers. The central specialists committee and its subcommittees became a forum for the popularization of the most broadly developed theoretical and technical as well as work organization achievements in the socialist states. In lectures, the earth ellipsoid by Krassowski and its derivation was compared to the revised reference ellipsoids, and the theory of the standard elevations in connection with the advances of Soviet scientists in the theory of the shape of the earth was discussed. The photogrammetric equipment designed and the methods which were worked out in this field in the USSR were also treated.

Every responsible coworker in the KDT had the obligation of devoting attention to the unhealthy splitting of our fatherland by German and American imperialism. Thus the lag in the unification of the geodetic foundations in the regions of West Germany, the processing of a triangulation network over all of Europe based on the American reference ellipsoid which, however, had no effect on the national economy surveying work but were taken over for topographical maps with a military significance, showed us that these measures are dictated by an agressive militarism.

Clearly established is the fact that the entire apparatus of the cadastral system and the so-called field measurement reform in West Germany serves to secure the monopoly of capital in agriculture. Many surveying personnel thereby are becoming stooges of the modern farmer expropriation. With us in the GDR, professional personnel have an essential part in carrying out the democratic land reform and the Geodesy FA has repeatedly discussed, together with farmers, the ways and means which we can employ in our work to still more rapidly and better further social progress in our country.

In the conferences of the specialist committee and its work committees we have worked out how the West German surveying system is being dragged on the two-rope of militarism. Cartographic work, for example, whose results serve chiefly for national education, is afflicted with the blemish of revenge. It cannot be overlooked that these technical achievements, still so worthy of recognition, serve reaction and not social progress. The road taken in West Germany in geodesy and cartography can therefore have no perspective for us.

With us, KDT work is being ever more oriented to the tasks to be fulfilled in services, offices, and institutes. The operational sections are becoming an important organ of each KDT member in geodesy and cartography. Of special importance was and remains the fact that the KDT members select the most capable and active professional colleagues in the executive committees and that the assignments for the section and its work groups are brought into harmony with the other social organizations and those in responsibility in the services in regard to the main assignments. In this manner also, many colleagues in geodesy and cartography are proceeding toward the realization of the decisions of the Second Congress of the KDT. Proceeding from this activity, the existing six professional subcommittees solve problems originating within a service or office. At the present time the specialist subcommittee for standardization and regulations heads the list; its drafts for uniform preliminary field and calculation forms are being currently introduced into the work process. The FUA (Fachunterausschuss) for cartography has developed into a center for exchange of experience, especially in regard to problems of map techniques in the GDR.

The successes achieved in the meantime in land surveying were able to be put into a larger framework, and additional assignments could be pointed up at the conference of the main specialist committee held in Leipzig in 1956. When the main committee treated the surveying and proposals system at Karl-Marx Stadt in 1957, an exhibit was given showing the activity of rationalizers and inventors in geodesy and cartography. The introduction of an administrative office for inventions in the sphere of the Ceodesy and Cartography Administration came out of this conference. Since then the number of proposals for improvement have increased.

The problems of educating and qualifying professional personnel in geodesy were the order of the day at the last conference. Here the necessary process of the closest connection of education with the production process in geodesy was discussed but was far from solved. It was indicated that the operational sections of the KDT had here to solve a responsible and necessary problem. Socialist reconstruction demands greater professional and political knowledge and capabilities from us all.

The Chamber of Technology is also an organizational framework in which exchange of experience and the friendliest connections with corresponding organizations in friendly

countries for the utilization of peaceful development and the construction of socialism can be maintained. The geodesy specialists committee was able in the last few years to make such connections with the union of geodesists and cartographers in Bulgaria, Poland, Hungary, and Czechoslovakia. KDT members were able to participate repeatedly in some of the professional conferences in these countries.

The professional colleagues from these countries were also guests at our own conferences; they actively participated at the conferences and thus conveyed to us their own experiences in their own countries.

On the tenth anniversary of our republic we can look back with full satisfaction on our voluntary technical association work, which has helped us to achieve our successes thus far. Each KDT member and each committee, by means of critical evaluation of the present work, can contribute with still greater success to increasing labor productivity and improving quality in the new large assignments which now stand before geodesy and cartography.

The main content of KDT work must now be directed to the problems and tasks of socialist reconstruction. KDT members must become the pacesetters of socialist association work and of cooperation between specialists, technicians, engineers, economists, and scientists. The technical processes are for the most part complicated; to decisively improve them requires that all relationships and connections in the production process be thought out. Further development will no longer be mastered by one specialist; many sides must be considered. It is therefore absolutely necessary in the further development of our production and in research and development work to systematically go over to complex work in socialist associations.

We enter the second decade of our socialist fatherland with the determined will to purposefully further the tasks which we have placed before us in the Seven-Year Plan, also through our KDT. We do this in the consciousness that the well thought out use of all our capabilities, of all technical and organizational possibilities for the rapid construction of socialism, is the only way to assure Germany the peace and the future and to obtain national reunion.

EAST GERMANY

Test Area for Geodetic Length Measuring Instruments

[The following is a translation of an article entitled "Eine Pruefstrecke fuer geodaetische Laengenmessgeraete" by Dr Engr F. Toepfer, Chamber of Technology, Dresden Advanced Technical School, published in Vermessungstechnik, Vol VII, No 11, November 1959, Berlin, pages 305-307; CSO: 3942-N/10]

According to the study plan of the specialist course on geodesy, students are to carry out a base line measurement with invar wires within the framework of a land surveying exercise. The students are not only to learn to know the method of measurement but must also be able to judge the accuracy of the invar wire measurement. For this the calibration of the invar wires before and after the base measurement is a prerequisite. Such field calibration measurements require a standardization section whose termina are so stably marked that their distance during a month--the time span between the two calibrations--can be regarded as unchanged.

Instrument tests are frequently carried out by the Geodetic Institute of the Advanced Technical School within the framework of teaching, research, and expertise, for which a measuring path must be available. In connection with the first assignment, the accuracy of the invar wire measurement must be utilized for the calibration of other length measuring instruments.

The measuring path must lie in the direct vicinity of the institute in order to compare laboratory investigations with field investigations shortly after they are carried out. In addition, the path requires a protected location free of traffic.

Local conditions made it necessary in considering these points of view to give up the desired longer section. The most favorable solution was found in a path 80 meters long and four to eight meters wide on the north side of the Beyer-Baus of the Advanced Technical School, close to the institute areas. This testing area had the further advantage of lying for the greater part of the day in the shade of the Beyer-Baus

and of allowing the calibrations to be carried out unhindered by sun's rays. In addition, vertical test measurements are possible in conjunction with the balconies of the Beyer-Baus.

Testing Area Installations

The invar wire measurement required monumenting at intervals of 24 meters, whereby the reading markers are to be located 0.70 meters above the ground. As these reading markers were to be station marks at the same time, granite posts which projected 0.70 meters from the ground were set up as the most favorable form of monumenting. Figure 1 shows the setup of both main posts situated at an interval of 72 meters.

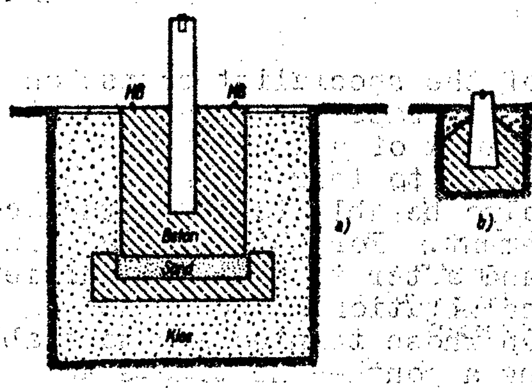

Figure 1

Monumenting the Testing Area

HB = elevation bolts
Beton = concrete
Sand = sand
Kies = gravel

Two additional, simply based granite posts subdivide this area into three 24-meter sections.

The 72-meter area was expanded to 80 meters by two ground stations, each of which was set at a distance of four meters from the main posts. To obtain a 60-meter area, a third ground station was set up between the first two posts (each at a distance of 12 meters). The marking of the ground stations was carried out according to Figure 1b by means of concrete posts with inserted brass bolts and one-millimeter boreholes as center marks. Additional auxiliary points were distinguished only by stakes with nails in them.

In order to take readings on the scales of bands and wires, division marks were graduated on the posts; these marks projected four centimeters from the posts to assure the free tension of the wires. The posts were so dimensioned--cross-section 25 x 25 centimeters--that theodolites could also be set up on them. (Also, the comparison of post and tripod observations was thereby made possible among other

things.) As the 4-centimeter high wire pegs made a suitable installation and centering of theodolites impossible, they had to be changed for flat pegs with cross marks. Therefore, iron bolts with tpered boreholes were cemented into the top surfaces of the granite posts. The wire and flat pegs were equipped with appropriately working tapered plug pegs so that they could be inserted and changed according to need. It was determined with the aid of a measuring microscope that, even when the insert was inaccurately oriented, the forced centering of the measurement marks is assured to ± 0.01 millimeters. Linear eccentricities exist between the different measuring markers which are smaller than one millimeter and which were determined by angle measurement in a fachion similar to dropping a plumb line.

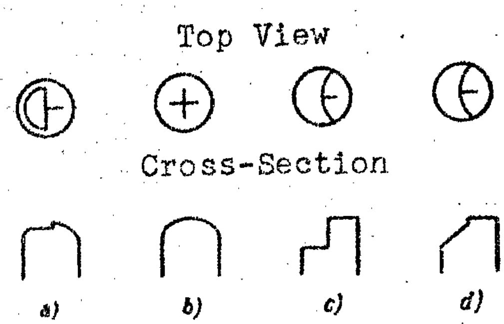

Figure 2

Head Form of the Reading Markers

The most favorable head form of the wire pegs was determined by an examination of the four forms illustrated in Figure 2.

Form 2a, available until now in the institute, was eliminated from the very beginning because heavy friction existing between scale and measuring mark owing to the edges and the horizontal contact surfaces, and in addition the reading is not free of parallax.

The danger of systematic errors resulting from the friction of the resting scale is also present in form 2b. With form 2c there is practically no friction in regard to the resting scale; however, parallax increases the effect of errors. In order to decrease this error influence, it was necessary to change over to form 2d, whose superiority is also shown by the discovered mean errors of a simple interval measurement:

Form	2b	2c	2d
Mean Error	± 0.101	± 0.108	± 0.089 mm

Steadiness of the Monumenting

A section was to be created by the described monuments on which geodetic length measuring instruments can be tested at any time without a previous comparison with standard measures. In addition to the determination of the area, this also requires the inspection of the area. We have to determine especially in what degree the changes in length suffer for the 72-meter area formed by the two main posts and planned for precision instruments. For this purpose, regular control measurements with invar wires were carried out at intervals of two months at the most; the results of these measurements are compiled in Figure 3.

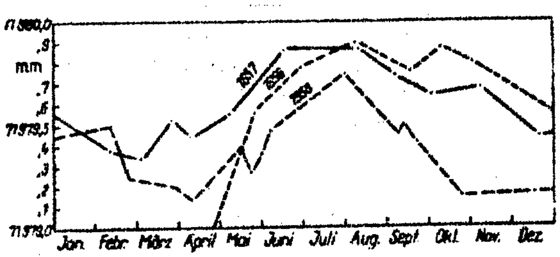

Figure 3

Course of the Changes in Length of the 72-Meter Section

The points had been marked in December 1955. The unavoidable phenomena of settling could be considered terminated by May 1956, or after six months. However, the posts have not come to rest. As Figure 3 indicates, the 72-meter section clearly indicates an annual progress which is disturbed by other accidental occurrences. For example--as indicated from a comparison of partial lengths not represented here--in November 1957 Post I suffered an additional jump-like change of at least 0.25 millimeters, which probably caused the deeper course of the 1958 annual curve. Post IV showed an especially strong change in the autumn of 1958. In September 1958 students carried out measurements on three days (within a five-day period). All three of these measurements are represented to show that the external accuracy of a length determination is at about ± 0.03 millimeters.

The reality of changes in length, especially the periodic ones, is confirmed by control measurements of elevations carried out regularly by means of precision leveling. For this purpose, elevation bolts (HB [Hoehenbolzen]) were inserted into the post foundations (Figure 1a). Many changes in length were confirmed by chronologically parallel running changes in elevation.

We shall report on this as well as on the probable causes of the changes in another connection. Here we shall only state for the sake of completeness that elevational fluctuations were established for posts up to $\pm$ 1 millimeter and for ground points up to $\pm$ 2 millimeters.

In the same manner we can draw the following conclusion from the length control measurements: the two main posts are stable within $\pm$ 0.5 millimeters (see Figure 3) while the positional change in the two more lightly grounded intermediate posts reached one millimeter. As the steadiness of the ground points need not be as high as that of the posts, only separate control measurements of smaller accuracy were carried out. These showed that positional unsteadiness relative to the main posts lies within $\pm$ 1.5 millimeters.

The Invar Measurements

The length measurement for the control of the 72-meter area was made with four invar wires; measurement with each wire was made twice forward and back. From the difference between these double measurements, the following resulted as the mean error of a double measurement (i.e., of the mean of the fourfold measurement of the 72-meter area with one and the same wire):

$$m_1 = \pm 0.06 \text{ mm}$$

To this corresponds a mean kilometric error of the simple forward and back measurement of $\pm$ 0.3 millimeters per kilometer. If the wire constants are known with sufficient accuracy, then the measurement with four wires corresponds to a fourfold double measurement. Under this condition, we obtain from m_1 as the mean error of the single determination of the 72-meter area:

$$M = \pm 0.03 \text{ mm}$$

If M is calculated from the discrepancies in the values of the four wires by their mean value, then theoretically the same value should result. Practically speaking, this cannot always by the case, because on the one hand an accidentally larger error in only four values will falsify the mean error, and because on the other hand the lengths of the invar wires are not stable to the required degree. In order to obtain the desired accuracy of $\pm$ 0.03 millimeters, the lengths of

the invar wires had to be at the same time inspected and in any given case corrected. A change in the wire constants was therefore undertaken whenever the results of the wire concerned on several measuring days systematically deviated from the total mean by more than 3 m_1 = 0.18 millimeters. Nevertheless, the lengths of each of the four wires had already been corrected after one year from the control measurements of the test area.

Naturally, doubts quickly arise as to the reality of the results with such a process--i.e., control of a changeable area with changeable length measuring instruments. As the lengths of the invar wires had been determined in the spring of 1956 in Potsdam, a new calibration was carried out on 3 June 1958 on the Potsdam comparison base. Unfortunately, this calibration was so disturbed by the lack of satisfactory care in transporting for the practice measurements and to Potsdam that it only afforded us the certainty that the lengths of the 24-meter invar wires were still correct within ± 0.05 millimeters after two years. A better result was obtained by the standardization carried out in December 1958 with four new calibrated wires suppled us the Soviet Union. Two of these wires agreed completely with the mean of the wires we had in this test. The deviation of the total mean of the new wires from the old wires amounted to 1:1,200,000. The conclusion is thereby justified that it was possible with the help of the 72-meter area to obtain the lengths of the invar wires with a relative accuracy of 1:500,000. This result showed how important it is that the wires be kept rolled up on cylinders and be unrolled only directly for measurements.

These two external length tests justify, on the other hand, the conclusion that:

1) the established changes in length in the 72-meter area are determined with an accuracy higher than ± 0.1 millimeters and are real;
2) the calibration of geodetic length measuring instruments is possible with an accuracy of 1:720,000 in connection with regularly carried out invar wire control measurements and in consideration of the way the length changes.

Therefore, a testing or calibration area was created by means of the described monument, which does justice to all practical requirements, excluding those of the base line measurement in land surveying.

If, according to what we have said above, we can consider the established lengths of the 72-meter area as valid, it is then possible to derive by a reverse process the changes in length of the invar wires from the control measurements. Such a procedure is of course not free of hypothesis, but nevertheless it permits a good look into the behavior of invar wires.

The deviations of the established wire lengths from 24.00000 meters at any given time are plotted over the time ordinate as abscissas in Figure 4. An especially short abscissa scale was included for each wire to characterize the actual dimensions. In December 1956 a break in the connecting point with the scale appeared for wire 825, whose correction brought about the shortening of the wire by 4 millimeters. The results of the Potsdam length determinations are highlighted by rings. The behavior of the wires in the measurements carried out in 1958 in connection with the Potsdam calibration show clearly to what degree the invar wire measurements can be unfavorably influenced by the jolting of the wires during transportation.

In Figure 4 large jumps take place, first of all for wires 0.3 and 05. Wire 03 altered its length sharply in November 1956 by about + 0.15 millimeters and in May 1958 by about - 0.25 millimeters; after one and a half years it again reversed the lengthening process. Wire 05, in addition to a sharp change in length in July 1956, shows the largest current changes. This is probably attributable to great torsion which adheres to the wire and its unfavorably located scale. The shortening of wire 04 in August 1956 could have been caused by a kink. Astounding, however, is the fact that the wire is apparently beginning to compensate again only after almost a year. The course of the changes in length for wires 04 and 825 finally indicate that, besides the sharp changes in length of smaller and greater amounts, slow systematic lengthening (04) and shortening (825) of the invar wires can also appear.

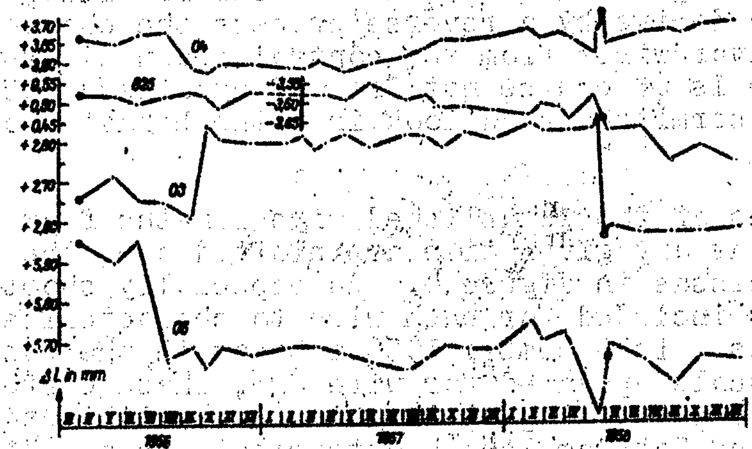

Figure 4

Course of Change in Length in
24-Meter Invar Wires

lications

e testing area for geodetic length measuring instruments so far performed the following valuable services in ful- ling the following assignments:

1. Determination of the legnths of 24-meter invar wires tapes. A calibration accuracy of 1:200,000 is assured on 72-meter area at any time.

2. Calibration of tape dimensions of other lengths; 25-meter, meter, and 50-meter tapes can be directly calibrated on the meter and/or 48-meter areas. Other lengths can be duced easily with the required accuracy by means of a ative interpolation of a reading marker on the tripod. h a calibration is especially favorable for measuring es, which are to be used free of tension because they cor- pond to field conditions.

3. Determination of the exact lengths of 2-meter rigid tense bars. As a sufficiently exact testing area is avail- e, the accuracy of this calibration is only a question of surement setup and expenditure of time. The most econo- al solution consists in setting up the theodolite in the

middle of the 24-meter area and in centering the subtense bars one after the other on both posts. With regard to the centering accuracy, an accuracy of length determination of the subtense bar is guaranteed within ± 0.05 millimeters (1:40,000) with this measurement setup.

4. Testing of the constants of tachymeter theodolites, reduction tachymeters, etc. For the testing of addition constants, 4-meter and 12-meter areas whose lengths are certain to ± 1.5 millimeters are available. The retesting of multiplying constants is possible on the 72-meter and 80-meter area with accuracies of 1:100,000 and 1:20,000 respectively. Also, the second possibility will still do full justice to the requirements.

5. The measurement path, because of its favorable location, has proved to be an indispensable aid for cursory field-type testing of different instruments. As an example we will mention only leveling instruments for whose retesting and adjustment--also target error determination, etc.--the installations of the testing area have already been frequently utilized.

1907

EAST GERMANY

Arrangements and Accuracy of Laplace Azimuths in Major Geodetic Networks

[The following is a translation of an article entitled "Zur Anordnung und Genauigkeit Laplacescher Azimute in geodaetischen Hauptnetzen," by Dipl Engr M. Schaedlich, Leipzig Geodetic Service, published in Vermessungstechnik, Vol VII, No 11, November 1959, Berlin, pages 317-322; CSO: 3942-N/11]

1. Posing the Problem

Laplace azimuths are located in large-scale geodetic networks in the vicinity of base lines. The latter serve to control network orientation, whereas the side conditions essentially influence the scale of the network.

Development has shown that the accuracy of the Laplace azimuths generally does not correspond to that of a control element. Krassowski[1] and Kneissl[2] deduced from the discrepancies in alternate azimuths the absolute errors in the astronomical orientation of a main triangle leg of $\pm$ 1."0 and $\pm$ 0."7 respectively with a systematic part > 0."5. Kohlschuetter already made the proposal in 1924 to select the number of single directions to be comgined into a calculation azimuth as >2.

In Finland, after the introduction of wireless time signals, they went over to determining a Laplace azimuth on each point of the southern chain with a minimum expenditure of labor (six to twelve series, one to two longitude evenings). Bonsdorff[3] deduced later that the side errors in the individual points depended only somewhat on the distribution of the entire astronomical labor expenditure (azimuths and longitudes) within the chain.

With a correspondingly small weight, the individual azimuths lose their property as a control element with the increasing density of the Laplace stations. In this sense, they are still effective only as a totality, in that they force a mean orientation on the network, whose geometry, however, changes little. The astronomical measurements themselves eradicate the largest

art of the Laplace discrepancies. A disadvantage of this oncept lies, in addition to the significant increase in etwork limitations, in the increased expenditure of time n observation as compared to the group-like location of the zimuths. Here also enters the effect of the refraction of he sides on the orientation of longer geodetic lines, as as been shown empirically by Schuetz[4] and which was shown ecently in footnote 5.

In what follows we will establish accuracy criteria for he Laplace control azimuths in networks with measured ngles (directions) and sides, considering the complemen- ary relationships between azimuth and side conditions as ell as the possible influence of lateral refraction on the irection measurements. Longitudinal and side errors of deal triangle chains will be derived with incorrect control lements. As the error transmission in equilaterial theo- olite networks depends only somewhat on the form of the etwork, the accompanying analyses will be confined to simple riangle chains.

2. The Orientation of Geodetic Lines (Triangle Chains)

1. The Laplace Equation

If the astronomic azimuth A^a of a leg of a triangle, reduced to the reference surface, is compared with the geodetic value A^g obtained by transfer, the following orientation condition is obtained:

$$A^a - A^g = 0 \tag{1}$$

which, according to footnote 6, is as follows in the second approximation:

$$\begin{aligned} a_2 - A_1^g - (\lambda - L)_n \sin\varphi_2 - \xi_0 f_1(\lambda_{1,n}, \varphi_n) \\ + \eta_0 f_2(\lambda_{1,n}, \varphi_{1,n}, a_{1,2}) = 0. \end{aligned} \tag{1a}$$

Here $a_{1,2}$ are the astronomic azimuths measured at the terminal sides of the chain (Figure 1); L_n the geodetic lengths in P_n, $\lambda_{o,n}$, $\varphi_{o,n}$ the astronomic coordinates of the terminals $P_{o,n}$ and ξ_o, η_o the plumb deflection components at P_o. The functions $f_{1,2}$ are of the order of magnitude of 10^{-2}. In addition, the following approximation is satisfactory for $\xi_o, \eta_o < 10''$:

2) $$a_2 - A_2^a - (\lambda - L)_n \sin\varphi = 0$$

r, according to Figure 1:

3) $$a_2 - (\lambda - L)_n \sin\varphi - \left\{ a_1 - (\lambda - L)_0 \sin\varphi + \alpha_1 + \alpha_{3(2n-1)} + \sum_1^{n-1} \beta_i + \sum_1^{n} (\Delta A_i + 180^\circ) \right\} = 0.$$

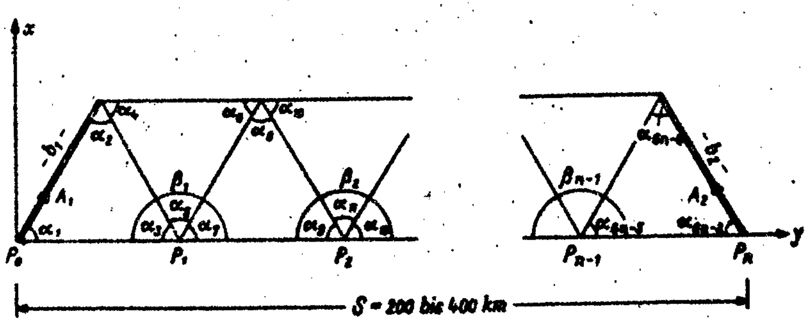

Figure 1

S = 200 to 400 kilometers

$\Delta A_i = \Delta L_i \sin \varphi_{mi}$ are the meridian convergences between .he separate stations of the transit traverse $P_{0..n}$. In the ;pecial case $\zeta_0 = \eta_0 = 0$ becomes $(\lambda - L)_0 \sin \varphi = 0$. In the ıdjustment, the angle β_i is replaced by the corresponding .riangle angle a_i and the direction differences respecitively; 3) then takes the form:

3a) $$v_{A_2} - v_{A_1} + \sum_1^{2(n+1)} (v_{r_{2(i+1)}} - v_{r_{2i+1}}) - w_L = 0$$

:he "astronomic dimension"

3b) $$v_{A_{1,2}} = v_{a_{1,2}} - v_{\lambda_{0,n}} \sin\varphi$$

ıre the corrections to the reduced azimuths A^a, v, the cor- 'ections to the measured directions, and the absolute term r_L is the "Laplace discrepancy." The latter is relatively .nappreciable as compared to the errors in the geodetic ılements. The Laplace equation can therefore be established ıt the same time with the triangle and side conditions.

2. Triangle Chains with Angle and Direction Measurement

1. The effect of accidental observational errors on the length and orientation of triangle chains. In the classical method of triangulation, the sides s_i of the transit traverse $P_{0..n}$ are determined indirectly from the measured triangle angles α_i and the terminal sides $b_{1,2}$. The latter provides a side condition of the form:

$$f(b_1, \alpha_{1\ldots 3(2n-1)}) - b_2 = 0. \tag{4}$$

The one-sided effect of (3) and (4) on the side and/or longitudinal errors in the chains necessarily follows from the nature of the azimuths as orienting elements and of the base lines as scale-determining factors.

In the adjustment of measured angles, the theory of error transmission for the weight reciprocals Q of the terminal point coordinates of an equilateral triangle chain whose side and azimuth conditions are in agreement with Figure 1 according to footnote 7 gives:

$$Q_1 = Q_q \tag{5}$$

The asymmetry in (5a) follows from the relation of the direction corrections to the total triangle errors of closure, whereas the angular corrections are determined only by the accompanying triangle of error. The following then holds true for $n = 10$ polygonal sides:

$$Q_1 > Q_q \tag{5b}$$

The adjustment according to the measured directions brings accordingly a significant correction to the chain orientation, which, in case only accidental errors are effective, is not without significance for the required accuracy of the Laplace azimuths.

The introduction of error-free azimuths and terminal sides respectively in conditions (3) and (4) are then justified, whenever at any given time the mean error of the transfer strongly outweighs those of the measured azimuths and terminal sides, or become the following ratios:

$$\left.\begin{array}{l} K_1 = m_{A''}\sqrt{2} : \mu_r\sqrt{Q_{A''}} \\ K_2 = m_b\sqrt{2} : \frac{\mu_r}{\rho} b\sqrt{Q_s} \end{array}\right\} \approx 0 \tag{6}$$

According to footnote 8, the weight coefficients $Q_{A,b}$ of the terminal side of a free equilateral chain adjusted according to the measured directions reads:

(6a)
$$Q_A \approx {}^1/_3(2n-1)+1,$$
$$Q_b \approx {}^4/_3(2n-1).$$

With a relative mean error of:

(7)
$$m_b : b = \pm 2 \cdot 10^{-6} \triangleq \frac{\pm 1}{500000},$$

the unit of weight error $\mu_r = \pm 0''.3$ and $n = 10$ polygonal sides becomes $K_2 = 0.4$. In newer networks therefore, a final weight is assigned not only to the Laplace azimut s but also to the base lines and/or terminal sides.

The values of the ZEN (Central European network) imparted for (6), according to footnote 9:

(7a)
$$0{,}7 \leq K_1 \leq 6{,}2$$
and
$$0{,}2 \leq K_2 \leq 3{,}2$$

incidate that the available azimuth and base line measurements do not sufficiently control the orientation and the scale of the chains. The sequence presents difficulties in including the supplementary scheme of triangulation.

We investigate how far in the introduction of final weights $p_{A,b}$ the symmetry in (5) is disturbed and observe the case of the balanced arguments:

(7b)
$$p_{a,A,b} = 1.$$

This definition corresponds to the ratios in practice, insofar as the mean angular errors and the Laplace azimuths

(7c)
$$q : {}^{q}m\partial = {}^{v}m_{m}$$

in the above relative side errors in regard to experience are measured with $\pm 0''.4$.

The 2n + 1 linearized, even conditions read (Figure 1):

(8)
$$\left.\begin{array}{l}
v_{\alpha_1}+v_{\alpha_2}+v_{\alpha_3} \qquad\qquad -w_1 = 0\\
\qquad v_{\alpha_4}+v_{\alpha_5}+v_{\alpha_6} \qquad -w_2 = 0\\
\qquad\qquad \cdots\cdots\cdots\cdots\cdots\cdots\\
\qquad\qquad v_{\alpha_{4n-3}}+v_{\alpha_{4n-2}}+v_{\alpha_{4n-1}} - w_{2n-1} = 0\\
v_{A_1}-v_{A_2} \quad +v_{\alpha_1} \quad +v_{\alpha_4} \quad +v_{\alpha_5} \quad +\cdots+v_{\alpha_{4n-3}} - w_{2n} = 0\\
v_{b_1}-v_{b_2}+\frac{1}{\sqrt{3}}\left\{-v_{\alpha_3} \quad +v_{\alpha_5}-v_{\alpha_6} \quad +v_{\alpha_8}-v_{\alpha_9}+\cdots+v_{\alpha_{4n-2}}\right\}-w_{2n+1}=0.
\end{array}\right\}$$

The last of the equations (8) is the linearized side condition in agreement with

(8a)
$$b_2-b_1\frac{\sin\alpha_2\sin\alpha_6\sin\alpha_7\ldots\sin\alpha_{4n-2}}{\sin\alpha_3\sin\alpha_5\sin\alpha_8\ldots\sin\alpha_{4n-3}}=0$$

with $b_{1,2} = s_i = 1$. The corrections v_i are understood in the arc measure.

For the weight of a function F of adjusted elements, the following holds in the case of balanced arguments and r conditions:

(9)
$$Q_F=\frac{1}{P_F}=[ff]-\left\{\frac{[af]^2}{[aa]}+\frac{[bf\cdot 1]^2}{[bb\cdot 1]}+\cdots+\frac{[rf\cdot(r-1)]^2}{[rr\cdot(r-1)]}\right\}$$
$$=[ff]-[C_i]_{r-1},$$

whenever

(9a)
$$\Delta F=F(Z_{1,2\ldots})-\Phi(Z'_{1,2\ldots})=\left[-\frac{\partial\Phi}{\partial Z_i}v_{zi}\right]=[-f_iv_i].$$

According to Figure 1, the coordinates of the terminus P_n reads:

(9b)
$$\left.\begin{matrix}x\\y\end{matrix}\right\}_{P_n}=s_1\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}(A_1+\alpha_1)+s_2\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}(A_1+\alpha_1+\alpha_3+\alpha_5+\alpha_7)+\cdots$$
$$+s_n\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}(A_1+\alpha_1+\alpha_3+\cdots+\alpha_{4n-5}).$$

If the sides s_i are expressed by means of the measured arguments, we then have:

(10)
$$\left.\begin{matrix}x\\y\end{matrix}\right\}_{P_n}=b_1\frac{\sin\alpha_2}{\sin\alpha_3}\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}(A_1+\alpha_1)$$
$$+b_1\frac{\sin\alpha_2\sin\alpha_6\sin\alpha_8}{\sin\alpha_3\sin\alpha_5\sin\alpha_9}\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}(A_1+\alpha_1+\alpha_3+\alpha_5+\alpha_7)$$
$$+\cdots+b_1\frac{\sin\alpha_2\sin\alpha_6\ldots\sin\alpha_{4n-6}}{\sin\alpha_3\sin\alpha_5\cdots\sin\alpha_{4n-5}}\left.\begin{matrix}\cos\\ \sin\end{matrix}\right\}$$
$$\times(A_1+\alpha_1+\alpha_3+\cdots+\alpha_{4n-5}).$$

From (10) follows with $\cot \alpha_1 = \frac{1}{\sqrt{3}}$ by differentiation:

.1)
$$
\begin{aligned}
v_x &= n\,(v_{A_1} + v_{\alpha_1}) + (n-1)\,(v_{\alpha_4} + v_{\alpha_5} + v_{\alpha_7}) \\
&\quad + \cdots + v_{\alpha_{6n-5}} + v_{\alpha_{6n-7}} + v_{\alpha_{6n-6}}, \\
v_y &= -n v_{b_1} - \frac{1}{\sqrt{3}} \{ (n-1)\,(v_{\alpha_1} + v_{\alpha_4} - v_{\alpha_6} - v_{\alpha_3}) + v_{\alpha_2} - n v_{\alpha_3} \\
&\quad + (n-2)\,(v_{\alpha_7} - v_{\alpha_{10}} - v_{\alpha_{12}} - v_{\alpha_{13}}) \\
&\quad + v_{\alpha_9} + v_{\alpha_{16}} + \cdots - v_{\alpha_{6n-4}} + v_{\alpha_{6n-3}} \}.
\end{aligned}
$$

The functions (11) are joined alternately with system (8)
; an additional condition. The result is then the normal
[uation and weight coefficients represented in Table 1

Table 1. Equations (12)

K_1	K_2	K_3	K_4	$\ldots$	K_{2n-1}	K_{2n}	K_{2n+1}	$[if]_x$	$[if]_y$
3	0	0	0	$\ldots$	0	2	0	$2n-1$	0
	3	0	0	$\ldots$	0	1	0	$n-1$	0
		3	0	$\ldots$	0	2	0	$2n-3$	0
			3	$\ldots$	0	1	0	$n-2$	0
			$\ldots$	$\ldots$	$\ldots$	$\ldots$	$\ldots$	$\ldots$	$\ldots$
					3	2	0	$2n-(2n-1)$	0
						$3n+1$	0	$\frac{n}{2}(3n+1)$	$-\frac{n}{\sqrt{3}}$
							$\frac{4}{3}(n+1)$	$-\frac{n}{\sqrt{3}}$	$-\frac{2}{3}n(n+1)$
							$[ff]_{x,y}=$	$\frac{n}{2}(2n^2+n+1)$	$\frac{n}{9}(4n^2+6n+5)$

In the reduction of this system in agreement with (9),
ıe following arithmetic series appear:

.3)
$$
\left.
\begin{aligned}
&\sum_{i=1}^{n-1} i = \frac{n}{2}(n-1), \\
&\sum_{i=1}^{n-1} i^2 = \frac{n}{6}(2n^2-3n+1), \\
&\sum_{i=0}^{n-1} (2i+1) = n^2, \\
&\sum_{i=0}^{n-1} (2i+1)^2 = \frac{n}{3}(4n^2-1).
\end{aligned}
\right\}
$$

With (13) then, the following expressions for the weight
:ciprocals of the side and longitudinal errors of the ob-
:rved chain result:

.4)
$$
\begin{aligned}
Q_q &= \frac{n}{2}(2n^2+n+1) - \frac{n}{36(n+1)}(32n^3+38n^2+13n-2), \\
Q_l &= \frac{n}{9}(4n^2+6n+5) - \frac{n^2}{12(n+1)}(4n^2+8n+7).
\end{aligned}
$$

The reduction terms on the right hand side represent the effect of conditions (8). It thus follows by conversion:

(14a) $$q = l = \frac{\mu_{\cdot}}{\varrho} s \left\{ \frac{n}{36(n+1)} (4n^3 + 16n^2 + 23n + 20) \right\}^{\frac{1}{2}}.$$

The symmetry in the accumulation of error in angle networks is accordingly independent of $p_{A,b}$, so long as the latter are equal. The mean error striven for in the orientation of the terminal side then reads, with the previously given mean error (7):

(15) $$m_A = \varrho m_t : b = \pm 0\overset{\prime\prime}{.}4.$$

Because of

(15a) $$m_A^2 = m_a^2 + m_\lambda^2 \sin^2 \varphi$$

there follows for the mean errors in the mean azimuth α with $m\lambda = \pm\, 0''.3$ in the mean lattitudes:

(15b) $$m_a = \pm 0\overset{\prime\prime}{.}3,$$

A later work will show that the absolute accuracy of newer azimuth measurements is identical with (15b). In the adjustment by directions, the criteria (15) would be increased by $\sqrt{3}$ in agreement with (5b). A more favorable accumulation of error in networks of this type is illusory, however, in the presence of systematic influences. Even more, the tolerances to be evaluated of just such circumstances must be taken into account (see below).

Baeschlin[10] places the following requirement on the accuracy of the astronomical part of the Laplace equation:

(15c) $$m_{a_1}^2 + m_{a_2}^2 + m_{\Delta\lambda}^2 \sin^2\varphi \leq \frac{\mu^2}{2} (n+1).$$

From this it follows for $m_{a_1} = m_{a_2}$:

(15d) $$m_A^2 \leq \frac{\mu^2}{4} (n+1).$$

With the mean direction errors $\mu_r = \pm 0''.3$ and $n = 10$ lygonal sides:

$$m_A \leq \pm 0''.6$$

5e) or

$$m_o \leq \pm 0''.4$$

in agreement with (15).

2. The effect of lateral refraction on the orientation the triangle chains. Schuetz derives from the effect of e Laplace azimuths in the networks of "plumb deviations B" d the longitude degree measurements at the 52nd parallel e mean systematic direction correction

6) $$(\delta r)'' = -R \cdot s^{km} \cdot \sin A$$

th

6a) $$R = \frac{0''.4}{100\,\text{km}}$$

pmann[11] indicates the effect as the result of a drop in an temperature of 0.6 degrees centigrade directed from uthwest to northeast and appearing in the direct vicinity the stations. The deformation of a term of the observed ain according to (16) is shown in Figure 2 and its bending the absence of Laplace conditions in Figure 3:

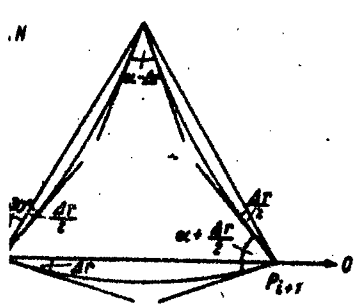

Figure 2

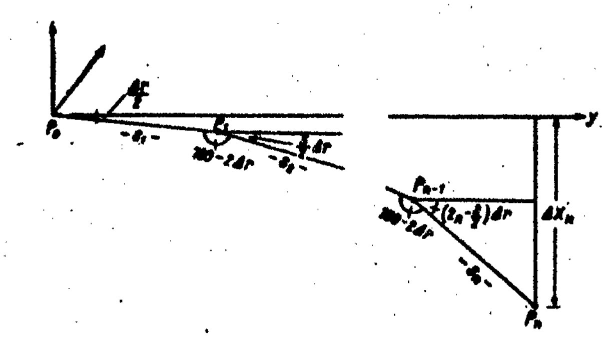

Figure 3

The side error in P_n becomes:

(17) $$\Delta x_n = \frac{\Delta r}{2\varrho} s \cdot n(2n-1) \approx \frac{\Delta r}{\varrho} s \cdot n^2.$$

When s = 25 kilometers, n = 10, and in agreement with (16a)

(17a) $$\Delta r = (\delta r)^{25\,km}_{max} = -0.''10$$

we obtain:

$$\Delta x_n = -1.2\,m.$$

(17b)

The effects of an accidental nature affect, in the case of adjusted angles, the following side error in a free chain[7]:

(18) $$m_{x_n} \approx \frac{2}{3} \frac{\mu_\alpha}{\varrho} \cdot s\sqrt{n^3},$$

and in the case of adjusted directions:[8]

(19) $$m_{x_n} = \frac{\mu_r}{\varrho} s \sqrt{\frac{2}{3} n^3}.$$

A comparison with (17) shows that in longer chains with the named R, the systematic bending greatly overweighs the accidental part.

The error in the transferred azimuth A_2^g becomes, according to Figure 2 and 3:

(20) $$\Delta A_2^g = \Delta r(2n-1) = -1.''9,$$

and in errors of an accidental nature with $\mu_\alpha = \pm 0''.4$:

(21) $$m_{A_2^g} = \mu_\alpha \sqrt{\frac{4}{3} n} = \pm 1.''5.$$

The effect of the systematic effects to be expected in regard to transverse displacement and terminal side orientation in east-west directed chains from 200 to 300 kilo-

meters in length is accordingly somewhat similar to any given transfer errors.

That postulate (15) and the weight of the Laplace azimuths respectively:

(21a)
$$p_{\Delta} a = \Gamma$$

satisfactorily helps to remove the transverse displacements as indicated by S_{igl}^{12} in the calculated example. The residual displacements within the chain prove, as in the case of the accidental errors, to be quite independent of the distribution of the astronomical labor expenditure. On the contrary, they stand in interrelation with the network configuration because of the systematic character of (16). It cannot be expected that the usual network adjustment will give the most probably station locations in the sense of the method of least squares. As the maximum deviations of the side coordinates from their most probable values in chains which are not too long always lie within the mean error with a sufficiently sharp terminal side orientation, the concept of the complementary role of the Laplace azimuths as compared to the measured base lines also appears justified in this case. The present measuring technique reaches the absolute accuracy of $m_A = < \pm 0''.5$, with a relatively small expenditure of labor, so that the establishment of azimuth nests becomes superfluous. In each case, the observation of two back azimuths suffices, eventually, according to two different methods.

The azimuth arrangement in main geodetic networks is therefore not finally always the object of discussion, because the problem of the orientation of the geodetic lines replacing the chains for the purpose of plumb deviation adjustment is most closely connected with the problem of the inner residual bending of the chains. The advantage of sharp control azimuths appears especially in an eventual changeover to network reinforcement or direct side measurement by means of electrical methods, as then the error transmission is influenced strongly in favor of Q_1 (see below).

A completely different problem is the concentration of the astronomic measurements in areas with greater plumb line deflections for the purpose of the reduction of geodetic data to the reference surfaces. Here a corresponding measurement accuracy is in order, owing to the small size of the corrections.

In the application of surface configurations to the derivation of superposed triangles or rectangles, the developed viewpoints in regard to arrangements and accuracy of the Laplace azimuths in theodolite networks do not change essentially because of the small dependence of the transfer errors on the network form.

3. Triangle chains with side measurement. In the application of surface configurations, probably the geometry as well as the scale of the chains is determined by the same measuring element. The latter is for r sides r - 1 times redundant in determination. It must therefore be expected that the longitudinal error in an equilateral, free chain is essentially smaller than its side error. According to footnote 13, the following holds true under an error-free orientation of the line of departure for the weight reciprocals at P_n:

$$Q_l : Q_q \approx 1 : n^2 \quad \text{or} \quad l : q \approx 1 : n \tag{22}$$

Equation (22) indicates that the area measuring triangulation requires a significantly greater expenditure as compared to the theodolite networks in exact azimuth observations.

The equilaterial, simple triangle chain with the oriented polygonal sides s_i (Figure 4) supplies the n - 1 Laplace linearized conditions:

$$\left.\begin{aligned}
v_{A_1} - v_{A_2} + v_{\alpha_1} + v_{\alpha_2} + v_{\alpha_3} - w_1 &= 0 \\
v_{A_2} - v_{A_3} + v_{\alpha_4} + v_{\alpha_5} + v_{\alpha_6} - w_2 &= 0 \\
\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots & \\
v_{A_{n-1}} - v_{A_n} + v_{\alpha_{3n-5}} + v_{\alpha_{3n-4}} + v_{\alpha_{3n-3}} - w_{n-1} &= 0.
\end{aligned}\right\} \tag{23}$$

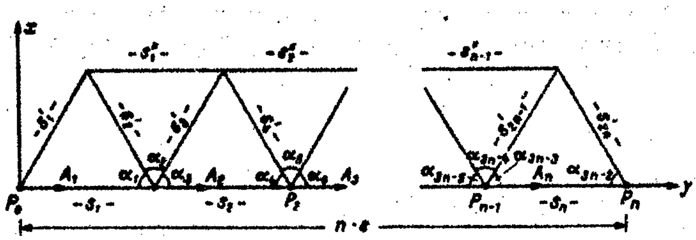

Figure 4

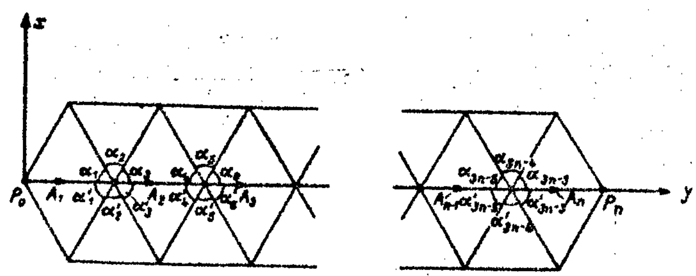

Figure 5

The corrections v_α must, as a function of the side corections v_s, be represented. If the half angle set is ifferentiated:

23a) $$2 \ln \tan \frac{\alpha}{2} = \ln \sigma_b + \ln \sigma_c - \ln \sigma - \ln \sigma_a,$$

here then results, after substitution of the differentials rom

23b)
$$\begin{aligned}
\sigma &= \frac{1}{2}(a+b+c) \\
\sigma_a &= \frac{1}{2}(-a+b+c) \\
\sigma_b &= \frac{1}{2}(a-b+c) \\
\sigma_c &= \frac{1}{2}(a+b-c)
\end{aligned}$$

nd transfer to the equilaterial triangle, the known elation:

24) $$d\alpha = \frac{1}{s\sqrt{3}}(2\,da - db - dc)$$

ith s = a = b = c.

System (23) then becomes:

25)
$$\begin{aligned}
&v_{A_1} - v_{A_2} + \frac{1}{s\sqrt{3}}(-v_{s_1} + 2v_{s_1'} - 2v_{s_2'} + 2v_{s_1''} - 2v_{s_3'} + 2v_{s_4'} - v_{s_2}) - w_1 = 0 \\
&v_{A_2} - v_{A_3} + \frac{1}{s\sqrt{3}}(-v_{s_2} + 2v_{s_3'} - 2v_{s_4'} + 2v_{s_2''} - 2v_{s_5'} + 2v_{s_6'} - v_{s_3}) - w_2 = 0 \\
&\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\
&v_{A_{n-1}} - v_{A_n} + \frac{1}{s\sqrt{3}}(-v_{s_{n-1}} + 2v_{s'_{2n-3}} - 2v_{s'_{2n-2}} + 2v_{s''_{n-1}} - 2v_{s'_{2n-1}} + 2v_{s'_{2n}} - v_{s_n}) - w_{n-1} = 0.
\end{aligned}$$

The corrections $v_{A,s}$ are in the arc measurement. We
;ain search for the weight reciprocals of the coordinates
the terminus P_n for the case of the balanced arguments
, A_i. It is (Figure 4):

25a)
$$x_n = \sum_{i=1}^{n} s_i \cos A_i, \qquad y_n = \sum_{i=1}^{n} s_i \sin A_i.$$

Differentiation gives us:

25b)
$$dx_n = \sum_{i=1}^{n} (\cos A\, ds - s \sin A\, dA)_i, \qquad dy_n = \sum_{i=1}^{n} (\sin A\, ds + s \cos A\, dA)_i.$$

For A_i = 90 degrees follows:

25c)
$$v_{x_n} = s(v_{A_1} + v_{A_2} + \cdots + v_{A_n}), \qquad v_{y_n} = -v_{s_1} - v_{s_2} - \cdots - v_{s_n}.$$

After multiplication of system (25) by $\sqrt{\frac{3}{10}}$, the follow-
ıg scheme is obtained for s = 1 for the normal equation
ıd weight coefficients:

26)

K_1	K_2	K_3	K_4	$\dots$	K_{n-1}	$[i/]_x$	$[i/]_y$
$\frac{14}{5}$	-1	0	0	$\dots$	0	0	$-\frac{2}{\sqrt{10}}$
	$\frac{14}{5}$	-1	0	$\dots$	0	0	$-\frac{2}{\sqrt{10}}$
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
					$\frac{14}{5}$	0	$-\frac{2}{\sqrt{10}}$
					$[//]_{x,y} =$	n	n

System (26) belongs accordingly to the group of "sym-
›trical forms," which make possible a representation of
ıe numerators and denominators of the reduction terms in
)) by means of chain fractions (footnote 14). We first of
.l observe the denominators from (9) and apply in what fol-
›ws the notation of Pringsheim:

26a)
$$\cfrac{1}{a + \cfrac{1}{a + \cfrac{1}{a + \cdots}}} = \frac{1|}{|a} + \frac{1|}{|a} + \frac{1|}{|a} + \cdots$$

From (26) it then follows:

$$(27)\qquad \left.\begin{aligned} &[aa]=\frac{14}{5},\\ &[bb\cdot 1]=\frac{14}{5}-\frac{1}{\frac{14}{5}},\\ &[cc\cdot 2]=\frac{14}{5}-\frac{1}{\frac{14}{5}-\frac{1}{\frac{14}{5}}},\\ &\ldots\ldots\ldots\ldots \end{aligned}\right|$$

It is then apparent that the limit value

$$(27a)\qquad \lim_{n\to\infty}[nn\cdot(n-1)]=\mu$$

satisfies the quadratic equation

$$(27b)\qquad \mu=\frac{14}{5}-\frac{1}{\mu}$$

From the two solutions

$$(27c)\qquad \mu_{1,2}=\frac{1}{5}(7\pm\sqrt{24})$$

the value $\mu = 2.38$ fulfills the equation (27a).

It further follows from (26):

$$(28)\qquad \left.\begin{aligned} &[af]_v=\frac{2}{\sqrt{10}};\\ &[bf\cdot 1]_v=\frac{2}{\sqrt{10}}+\frac{\frac{2}{\sqrt{10}}}{\frac{14}{5}},\\ &[cf\cdot 2]_v=\frac{2}{\sqrt{10}}+\frac{\frac{2}{\sqrt{10}}+\frac{\frac{2}{\sqrt{10}}}{\frac{14}{5}}}{\frac{14}{5}-\frac{1}{\frac{14}{5}}},\\ &\ldots\ldots\ldots\ldots \end{aligned}\right|$$

The limit value

$$(28a)\qquad \lim_{n\to\infty}[nf\cdot(n-1)]_v=\nu$$

is calculated from the relation

(28b) $$\nu = \frac{2}{\sqrt{10}} + \frac{\nu}{\mu}$$

to $\nu = 1.09$.

With

(28c) $$\lim_{n \to \infty} C_{n-1} = \frac{\nu^2}{\mu} = \frac{4\mu}{10(\mu-1)^2} = \frac{1}{2}$$

the weight reciprocals $Q_y = Q_l$ can be represented as follows:

(28d) $$Q_l = n - \left\{ \sum_{i=1}^{h} C_i + \frac{1}{2}(n-1-h) \right\}.$$

The selection of $h < (n - 1)$ is determined from the required accuracy. The numerical evaluation according to (27) and (28) gives for $\Delta Q<0.1$ ($h = 3$):

(29) $$Q_l = \frac{n}{2} + 1{,}3 \qquad (n > 2).$$

It follows from (26) for the weight reciprocal of the side error:

(30) $$Q_q = n$$

With $n = 10$ and the weight unit error $m_s = \pm 1$, the mean longitudinal and side errors of the chain become:

(31) $$\left.\begin{array}{l} l = m_y = \sqrt{Q_l} = \pm 2{,}5, \\ q = m_x = \sqrt{Q_q} = \pm 3{,}2. \end{array} \qquad (m_s = \pm 1) \right\}$$

In the adjustment of double chains (Figure 5), the n - 1 side (central) conditions

(32) $$\alpha_{3i-2} + \alpha_{3i-1} + \alpha_{3i} + \alpha'_{3i-2} + \alpha'_{3i-1} + \alpha'_{3i} - w_i = 0$$

must additionally be fulfilled. As α_i exclusively represent the function of the measured sides, system (32) has apparently no influence on Q_q. The $[if]_x$ remain equal to zero, whereas Q_l is again decreased.

For the two chain forms, the criterion

$$m_A < \rho m_s : s \tag{33}$$

can then be set up with regard to (31) to the azimuth location concerned. With the relative area error:

$$m_s : s = \pm 2 \cdot 10^{-6}$$

we have

$$m_A < \pm 0\overset{\prime\prime}{.}4 \quad \text{or} \quad m_A < \pm 0\overset{\prime\prime}{.}3. \tag{33a}$$

Still higher demands are thereby placed on the azimuth determinations than in the theodolite networs; (33) holds true in a corresponding azimuth arrangement also for square chains with one or two diagonals, as there the error transmission diagonally to the chain is similarly unfavorable.

In the derivation of superposed configurations from surface networks, the acute azimuth measurements must be correspondingly so located in area as to decrease the tangential errors in the "dominating" points (somewhat according to Figure 6). The preference of directions close to the meridian is therefore advantageous for reasons of technical measurement.

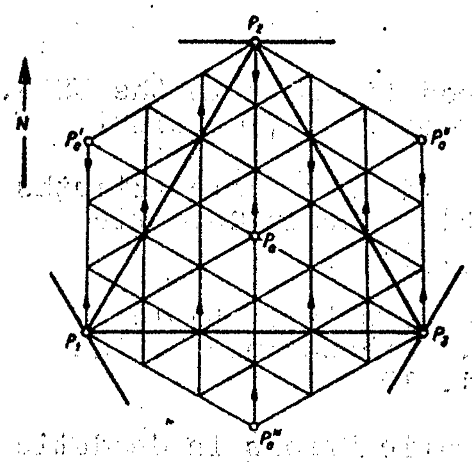

Figure 6

Systematic errors of geodetic elements naturally influence, in area networks, the location and accuracy of the Laplace azimuths to a lesser extent, as they essentially alter the scale. A prerequisite of network calculation is the exact reduction of the measured sides to the reference surface. In the direct measurement of longer geodetic lines (radar) networks), an analogous orientation of the latter is useful, approximately by a synchronous measurement in the terminals on a common target (high target, stars), or by calculating the absolute plumb line deflection $\varepsilon_{o,n}$. The latter method makes use of the circumstance that the influence of the more distant zones is practically the same on

the two terminals. One presupposes a corresponding density of the gravimetric measurements in a perimeter of several thousand kilometers.

3. Summary and Conclusions

The location of the Laplace points in main geodetic networks (theodolite networks) takes place effectively in the vicinity of the measured base lines. By equal, relative mean errors of the calculation sides and their azmuths, approximately the smme longitudinal and side errors are to be expected for the terminus of a triangle chain after adjustment and also in the presence of a noteworthy refraction vector.

In area networks, the required expenditure for exact azimuth measurements is significantly larger diagonally to the chain direction because of unfavorable error transmission. The practice of these networks therefore requires rational and exact, if possible simultaneous methods of the determination of the astronomical components.

Footnotes

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1907

EAST GERMANY

The Result of Map Production Methods on Forming Individual Map Signs

[The following is a translation of an article entitled "Die Auswirkung kartentechnischer Herstellungsverfahren auf die Formgebung einzelner Kartenzeichen" by Engr K. Ziemer, Chamber of Technology, Cartographic Service, Potsdam, published in Vermessungstechnik, Vol VII, No 12, December, 1959, East Berlin, pages 349-352; CSO: 3942-N/12]

In order to create ever better production conditions for the production of cartographic originals in regard to productivity and quality, mechanical, and partly also semi-automatic, aids are being used instead of the usual manual sign-making equipment (drawing pens, india ink, etc.). This is especially evident in the ever increasing use of the layer engravure method in map production. Here, however, a problem has arisen in map formation, which, on the surface, is of secondary importance but in the course of further technical development deserves more attention than it has been getting so far. This consists of the fact that the technique used affects the map picture in regard to form.

Each work process for the production of cartographic originals has so far brought new elements with it in the representation of individual map signs. We can indicate as an example that copperplate engraving, on the basis of its possibility of reproducing fine lines which are edge sharp, created conditions for the broad application of the hatched or section lined method in the representation of terrain on the former map of the German Reich, on a scale of 1:100,000. The same thing holds true for italicized script. Here it was the manner of stylus execution in engraving script curves which made it possible to create script which was well suited to the content of the map. This type of relationship between applied production technique and map content can be established everywhere with further investigation.

Thus initially the representation of relief by means of hatching could be broadly applied only by plotting on the lithographic stone with its granulated surface. The develop-

ment of the reproduction technique also shows its effect on the map content. We are indebted here to the introduction of the drawing techniques on paper and prints by means of pen, india ink, etc., because they created the conditions for the application of photographic methods and various copying methods in plate engraving production. The drawing technique created forms of the individual ornaments of map representation that were favorable for it, which we find in the sign directions of our topographical map works! They are adjusted to the work method involving drawing pen and bow compasses. The wedge-shaped representation of gradients shows a form which originates through the use of a drawing pen whose impression becomes ever stronger.

At the present time we are again at a stage where on method eventually eliminates another. We have begun to work in a new technique with the application of the layer engraving method. There are difficulties in engraving the different ornaments which have so far been typical of the drawing technique. This is especially true of the representation of gradients (dikes and intersections) and cultivation borders (Kultergrenzen).

These difficulties can be eliminated in the following ways:

1) the creation of new equipment with which to execute the old representation with the new technique;
2) the use of new ornaments which correspond to the new technical conditions.

The Creation of New Equipment

a) Dams and Intersections

Dams and intersections are frequently contained in topographical maps on scales of 1:10,000, 1:25,000, and 1:50,000. They are rppresented by many small thorn-type single forms which stand on a base line and take a relatively large part of the total work time in the production of cartographic originals. The cartographic draftsman must himself have a high degree of ability and concentration in order to reproduce the form most favorable to the drawing technique (an impression with the drawing pen which becomes stronger) uniformly on a map sheet with a quiet total impression (equal distances, form, and dimensions). In layer engraving, these

requirements are still greater because an engraving stylus does not produce a broader line by means of an impression on the glass plate which becomes stronger (on a print, the print material would be damaged). Here, therefore, the thorn-like form of the gradient elements must be obtained with a stylus which engraves with a line thickness of about 0.05 millimeters. It is thus necessary to first of all engrave the contour line for a single form with a base of 0.3 millimeters and a height of 0.5 millimeters and then remove the layer residues (the surface) which remain standing within the boundary. The engraving needle point, used manually, executes movements in this case which lie within a length area of 0.05 to 0.25 millimeters.

Tests broad in scope were carried out in order to obtain data on whether the manual engraving of gradients is possible, advisible in regard to time, and physically comfortable for the workers (s movement from 0.05 to 0.25 millimeters!). In order to create a time comparison between the drawing and engraving techniques, gradients 5 centimeters long were executed by cartographic draftsmen and cartographic engravers.[1]

The following average results were obtained:

Drawing per centimeter--2.5 minutes (5 minutes);
Engraving per centimeter--3.5 minutes (6 minutes);

The manual engraving times were obtained by coworkers who had already worked with the layer engraving method for longer than one year. The times in parentheses were obtained by less qualified workers.

The extra time expenditure in manual engraving amounted to one centimeter of gradient length on the average, as compared to the drawing technique. It could be assumed that this time loss was justifiable because the layer engraving method requires in toto a productivity about 30 percent higher than the drawing technique. Such a view is false, however, as quality requirements are not fulfilled in spite of the extra time expenditure. The smallness of the movements to be executed leads to a cramping of the hand and also more frequently to damaging the contour lines of the thorn-like form. A stronger magnifying glass must be used to control the work, and in spite of this the eyes become unduly strained. Therefore, manual engraving is not to be viewed as suitable for practice (Figure 1).

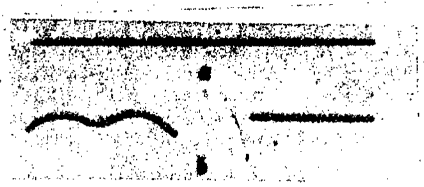


Figure 1

Gradient Representation

a) drawn gradient
b) manually engraved gradient

Attempts were also made to work in the gradients subsequently by means of the drawing or scraping method on the print of the engraving plates. Three variations were tested:

1. The gradients were engraved as thin lines with a line thickness of 0.05 to 0.08 millimeters (Figure 2a) and then strengthened on the engraving plate printing pattern with drawing pen and india ink (Figure 2b).

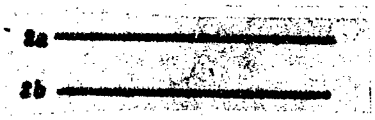


Figure 2

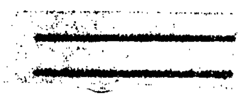


Figure 3

2. The gradients were engraved with a line thickness of 0.3 limeters and the point was obtained by scraping on the enving plate printing pattern (Figure 3).

3. The gradient lines were drawn on the printing pattern gure 1a).

All three variations are to be viewed only as temporary utions, as the durability and storage stability of the nting sheet was considerably reduced by them. The duraity of the "photoastralones" which were used as a rule impaired because either india ink was taken onto the atin layer or the layer was damaged by scraping work.

The situation was similar for the sheet prints (the prob- of the adherence of india inks to the prints). We uld mention at this point that the engraving of the dient lines for two of the above variations (Figures 2 3) was carried out with a device developed especially engraving line gradients. Gradients with uniform line ervals (different intervals can be obtained by means of hangeable optical parts) and uniform line lengths (ad-

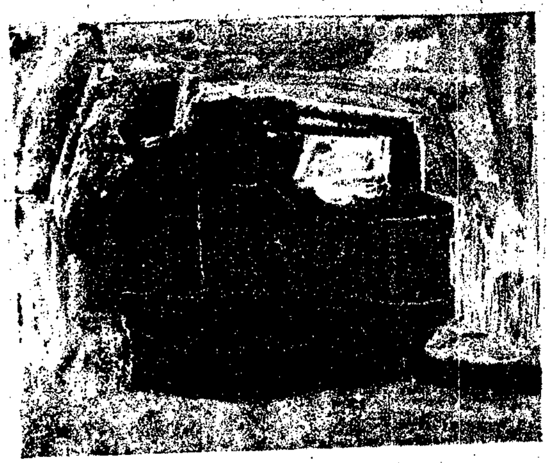


Figure 4

justable from 0.3 to 1.5 millimeters) can be engraved with this device (Figure 4). The line thicknesses can also be altered by exchanging the engraving tools.

The work time required for one centimeter of line gradient is 1.25 minutes.

As attempts to do engraving work of thorn-like gradients by hand brought no usable result, the requirement then was to carry out this work with the aid of a mechanically operated device. The need for a new supplementary device was supported by the frequency of gradients in scales of 1:10,000 and 1:25,000. Thus gradients with a total length of one to two meters are frequently contained in a map scale and beyond, each according to the type of relief and the density of the dwellings and traffic network on a map sheet, especially wherever streams, rivers, streets, and railroads run onto dams or into intersections. The first work results with the newly developed gradient device (Figure 5) were not satisfactory because an attempt was made to obtain the thorn form prescribed in the symbol key which runs out to a fine point (Figure 6b).

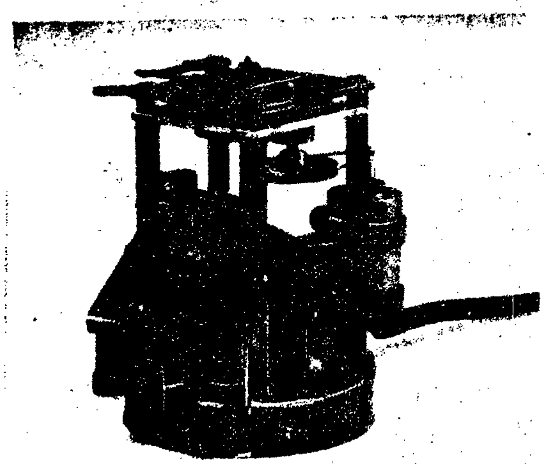


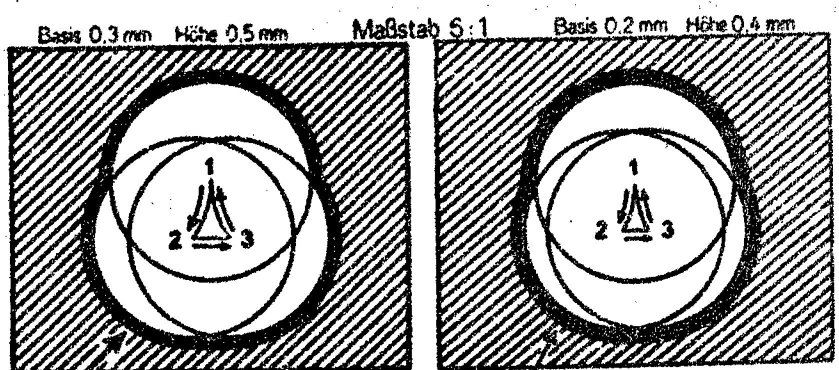
Figure 5

Figure 6

This form relies on the work with the drawing pen (this form is easy to obtain with a light initial touch of a drawing pen and then an impression which becomes stronger) and is not to be obtained by the principle used in this device.

A hollow stencil is scanned with a cylinder in the device for the purpose of decreasing friction (Figure 7). The diameter of this cylinder, however, determines the form. A cylinder diameter of five millimeters has proved satisfactory for production purposes. The movement of the engraving tool (among other things, a needle) is dependent on the movement which the center of the scanning cylinder executes. All triangle forms can be reproduced (Figure 6a).

Thorn-type map projections, in which two sides are parts of a parabola, cannot be obtained, as can be seen in Figure 7 without further explanation.



Scanning form of stencils
1-2-3 path movement of center of cylinder

Figure 7. Stencils for Gradients (Schematic Representation)

If, however, two sides of the figure are circular arcs, then forms can be obtained which leave behind a thorn-like impression (Figures 6c and 6d). Here there is a close relationship between the ratio of the width of the base to the height of a gradient line of this type. Thus the gradient ornament for map scales of 1:25,000, with a 0.3 [millimeter] width and a 0.5-millimeter height is a different form than the ornament for the scale of 1:100,000 with 0.2-millimeter width and a 0.4-millimeter height (Figures 6c and 6d).

Possibilities have been created in this device for engraving various forms of gradients by exchanging the line or dash marks of the optical parts, the stencils, and engraving tools (Figures 8a and 8b; the engraving of houses is also technically possible, 8d). Engraving of line gradients with long and short lines or dashes in one operation is also possible (Figure 8c). The working time for the ornaments in Figures 8a and 8b totals 2.5 minutes per centimeter and for Figure 8c 1.75 minutes.

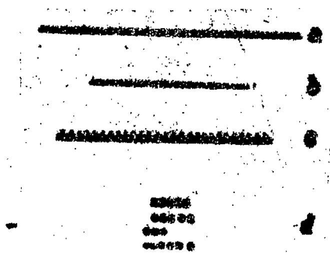


Figure 8

By creating a special device, the labor productivity as well as the quality in the engraving of thorn-type gradients can be increased as compared to the drawing technique, which is quite peculiar to this form, whereby now a uniformity can be obtained which was not possible before with the drawing method.

b) Cultivation Borders

Cultivation borders or man-made boundaries are represented in our topographic maps by point series. Considerable difficulties are also encountered in engraving these. It is worthwhile, however, to engrave a circular area with a thin needle in a point 0.2 millimeters diameter. If the obtained dash thickness lies under 0.1 millimeters, the layer remaining within the periphery must be removed. Here it is very difficult to obtain an approximately circular point. A series of points having a uniform form is not obtainable. The reasons for this are similar to those in the manual engraving of gradients in the smallness of the movements.

If the drawn cultivation boundaries are observed under a hair counter, it can be seen that a point only rarely has a circular form. Most points deviate from the circular form; in part, they are more or less polygon surfaces bordered by angles and sides. The conclusion involuntarily arises that a point is an element for the representation of cultivation boundaries which is not peculiar even to the drawing technique. With closer inspection it can be determined that the point is a characteristic feature of copperplate engraving. In copperplate engraving, a point is engraved in that a steel needle with a tapered point is pressed into the metal and varies the size of the point by the strength of the impression. The circular form of the point then occurs

automatically. On the basis of these considerations we must admit that cultivation boundaries in the form of point series made by the drawing technique will already have to be represented by another method.

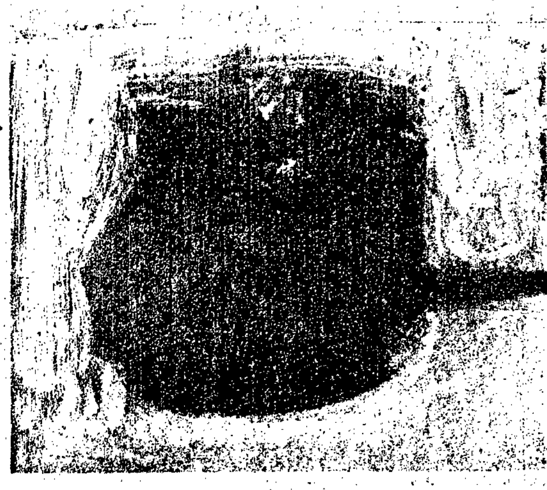


Figure 9

In order to overcome the the difficulties in engraving points, a device had to be created that would engrave points of a uniform form and at uniform intervals (Figure 9).

The Application of New Ornaments

We have explained in what we said above how we can circumvent certain difficulties which arise in transferring all ornament forms used in the drawing technique to the engraving method by the creation of special devices.

However, what will happen in the future? The representation forms of certain map elements which are determined by a technique previously applied (for example, the drawing technique or copperplate engraving) must either be maintained or replaced by different means of representation. In retaining the old forms, the situation will be that increases in labor productivity will be made possible only by creating special devices and using them. In addition, considerable funds must be expended for the production and procurement of such equipment. These methods are profitable to the extent that with newly developed equipment a higher performance will be obtained as compared to the drawing technique. They have, however, the great disadvantage that the increasing number of special devices for carrying out engraving work will be added to the available standard equipment.

A more favorable solution to these problems would be the use of altered or new forms of representation which can be represented with a minimum additional technical expenditure. A more rapidly working technical solution is found for gradients in a rectangular single form with a uniform line length (Figure 4). A device of this type can be more rapidly operated than a device for thorn-like gradients (Figure 5). The measurement of the line thicknesses and lengths as well as the intervals must be selected so that no confusion with other ornaments, such as fences or walls, will result.

Quite different methods of representation for gradients can be achieved with the use of colors. Starting at the upper edge of the gradient, which is so far represented, one could color the surface now filled out by the thorn-like gradient elements with full or half-tones. The production of this type of color covering would have to go more rapidly than the drawing or engraving of gradients. The color must be formed so that no additional color print would be necessary--for example, in brown (printed with relief plates), or as a half-tone in black for the purpose of differentiating natural and artificial gradients.

The cultivation boundaries would be technically more rapidly executed if they were represented as thin drawn out lines. One would have to indicate their line thicknesses once on the map or imprint them on the green plate. Forested areas could then be printed with a cross half-tone and the present line half-tones could be retained for young forests, etc. This type of color covering could be easily and economically produced by means of the strip-masking pricess. Contour plates produced by this method would make the application of a cut-transfer layer (Schneidabziehschicht) superfluous.

It would much appreciated if, on the basis of the produced designs, a greater number of professional colleagues were more intensively concerned with the relationships of the forms of cartographic representation means to the new technical work methods. The discussions originating thereby would create a basis for further development of map work. If the requirements of a new technique which has as its goal an increase in labor productivity and quality are taken into consideration in regard to the map symbol keys, then they could be introduced more rapidly and in greater scope.

1907 - END -